Contract No. FA64WA-5223

IBM Field Engineering

Theory of Operation

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9020 D/E System

Power Controls and Distribution

SFN-0105-2

PREFACE

This manual describes the theory of operation for power control and distribution within the IBM 9020D/E Systems.

The first chapter describes the overall system power control facilities. The next ten chapters describe in detail the power control and distribution functions for:

- Computing Element (CE)
- Input/Output Control Element (IOCE)
- Storage Element (SE)
- Display Element (DE)
- Peripheral Adapter Module (PAM)
- System Console (SC)
- Configuration Console (CC)
- Tape Control Unit (TCU)
- Data Adapter Unit (DAU)
- Direct Access Storage Facility (DASF)

Additional power information can be obtained from the SLT Power Supplies manual, and from the maintenance manuals for the above elements/units. These manuals are listed below for reference:

Manual	Form No.
Solid Logic Technology Power Supplies, FEMI	SY22-2799
7201-02 Computing Element, FEMM	SFN-0203
7231-02 I/O Control Element, FEMM	ZZ22-6823
7251-09 Storage Element, FEMM	SFN-0203
7289-04 Display Element, FEMM	SFN-0403
7289-02 Peripheral Adapter Module, FEMM	226-2027
7265-02 System Console, FEMM	226-2041
7265-03 Configuration Console, FEMM	SFN-0508
2803A Tape Control Unit, FEMM	SY32-6002
2701-01 Data Adapter Unit, FETMM	SFN-0901

Legend:
FEMI – Field Engineering Manual of Instruction
FEMM – Field Engineering Maintenance Manual
FETMM – Field Engineering Theory and Maintenance Manual

Second Edition (June, 1971)

This revision, Form SFN-0105-2, obsoletes the previous edition, Form SFN-0105-1, and adds Chapter 11 which describes the Direct Access Storage Facility (DASF). This revision also corrects minor errors and incorporates the latest engineering changes. Changed or added text (except for Chapter 11) is indicated by a vertical line to the left of the text; changed or added figures are denoted by the symbol • to the left of the caption.

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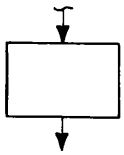
The following abbreviations are used in this manual. For a definition of system terms, refer to the glossary in the 9020E System Introduction FETOM.

ac	alternating current
ALD	Automated Logic Diagram
ATC	Air Traffic Control
CB	circuit breaker
CC	Configuration Console
CCR	Configuration Control Register
CE	Computing Element
C/I	converter/inverter
CLU	common logic unit
DAR	diagnose accessible register
DASF	Direct Access Storage Facility
DAU	data adapter unit
dc	direct current
DE	Display Element
DG	display generator
dly	delay
DSU	Disk Storage Unit
ELC	element check
EPO	emergency power off
EXC	Executive Control (Program)
F	Fahrenheit
F/R Pack	ferro/regulator package
Fr	frame
Hz	Hertz (cycles per second)
HV	high voltage
I/O	input/output
IOCE	Input/Output Control Element
K	relay
kHz	Kilohertz (thousand cycles per second)
LV	low voltage
ma	milliampere
MACH	maintenance and channel (storage)
MPO	master power off
MPS	medium power standard
N/C	normally closed (relay points)
N/O	normally open (relay points)
Nom	nominal
OBS	on-battery signal
OC	overcurrent
OTC	out of tolerance check
OV	Overvoltage
PAM	peripherial adapter module
PDU	power distribution unit
PS	power supply
RCU	reconfiguration control unit
RFI	radio frequency interference
RKM	radar keyboard multiplexer
rms	root mean square
ROS	read only storage
RR	reed relay
SC	System Console
SCCU	system console control unit
SCR	silicon-controlled rectifier
SCU	Storage Control Unit
SE	Storage Element
SLT	Solid Logic Technology
SMS	Standard Modular System
SSU	storage switching unit
SSW	side switch
SU	switch unit
SW	switch
TCU	tape control unit
TB	terminal board
UV	undervoltage
V	volt
VM	voltage marginable
VNM	voltage non-marginable

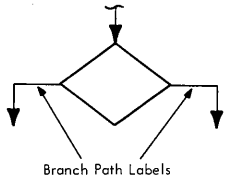
Legend

FLOWCHART



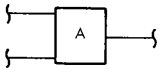
Processing Block

Manual Intervention Block

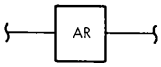


Decision Block

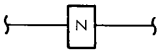
LOGIC DIAGRAM



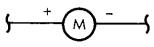
AND



Amplifier



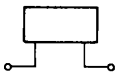
Inverter



Meter

Motor

Motor



Relay Coil

Normally Open Relay Point

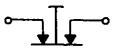
Normally Closed Relay Point

Relay Points

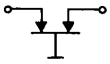
Contactor Points

Switch

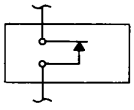
Pushbutton Switch



Pushbutton Switch

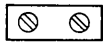


Pull Switch



Thermal Switch

Jack Switch (Inserting Plug Completes Circuit)



Terminal Board or Bus

Circuit Breaker

Circuit Breaker

Fuse

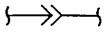
Lamp Indicator

Neon Indicator

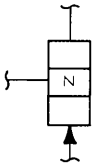
Thermistor

Silicon-Controlled Rectifier (SCR)

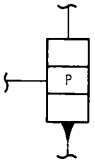
Zener Diode



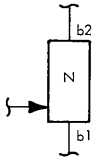
Disconnect



Transistor, Type N



Transistor, Type P



Unijunction Transistor, Type N
Position of Arrow Head Indicates Base 1(b1)

This chapter describes the system level aspects of power and those areas of power which are common to many of the elements and units. Information dealing specifically with individual elements is contained in later chapters.

INTRODUCTION

The 9020 D/E systems use 208V ac power which is distributed to all major elements and units directly from the facility power source. Some secondary units and devices receive power from the primary units to which they are attached.

System power control facilities are primarily on an individual element and unit basis because the entire system is not normally powered down. However, provision is made to power down the entire system in an emergency situation.

Provision is made for monitoring the status of the system power both by the operator (via indicators) and by the control program (via the 9020 program interruption capability).

Major elements and units are self-powered and contain the necessary equipment to convert the 208V ac into the particular voltages which they require.

Warning and protection facilities provide a continuous check on such conditions as under–or overvoltage, overcurrent, and overtemperature. Checking facilities are provided to permit maintenance personnel to detect and correct these conditions. The marginal checking facility permits certain critical voltages to be varied so that circuits that are operating marginally can be detected, often before a failure occurs.

Backup power is provided for certain elements in the 9020 D/E systems by means of batteries. The Computing Elements (CEs), the Input/Output Computing Elements (IOCEs), the Storage Elements (SEs), and the Display Elements (DEs) contain battery backup power to enable the program to continue to a logical stopping point in case of loss of mainline power. Line sensing circuitry makes possible automatic switchover to battery power when main power is interrupted.

The IBM 9020D/E is designed for 24-hour operation, requiring that a minimum configuration of elements and units be operating at all times.

The combining of individual elements and units into a system configuration imposes the need to coordinate individual power facilities. To achieve this coordination, the following system power control functions are provided:

1. The control program is provided the capability to restrict the manual removal of power from all elements and some units.
2. Loss of power at all elements, the Peripheral Adapter Module (PAM), the Tape Control Units (TCU), the Storage Control Unit (SCU), the Reconfiguration Control Unit (RCU) portions of the Configuration Console (CC), and the Data Adapter Units (DAU) is indicated to the control program. However, the DAU indications occur only if an I/O selection is attempted.
3. Element, PAM or data adapter unit (DAU), TCU, and SCU power indicators are displayed at the System Console and SCU (SC) or Configuration Console (CC).
4. Provision is made for the removal of all system power except prime power if an emergency situation occurs.
5. Some elements are equipped to detect the loss of input power and to automatically operate from a temporary sustaining power source.
6. The ability is provided for all system components to be returned automatically to a power-on status following the return of prime power.

Table 1-1 lists element and unit power control facilities for the primary elements and units within the system. These facilities are described below.

Power Interlocks

Power On/Off Interlock

The POWER ON/OFF switch is rendered incapable of initiating a power-off sequence whenever the element operational state, as specified by its CCR, is other than state zero with the TEST switch on.

MC Interlock

Marginal check excursion controls are slotted and recessed behind their control panels to prevent inadvertent operation of these potentiometers if they are located on the operator's panel.

Power On/Off Facilities

EMERGENCY PULL Switch

Activating this switch causes all output power to be removed from circuits and cabling outside the power

Table 1-1. Power Control Functions - 9020D and 9020E Systems

Function	System Component									
	IOCE 7231 -2	DAU 2701	PAM 7289 -2	TCU 2803 -1	SC 7265 -2	SE 7251 -9	CE 7201 -2	CC 7265 -3	DE 7289 -4	SCU 2314 -A1
Power Interlocks										
Power On/Off Interlock	X	NO	X	X	NO	X	X	X	X	X
M. C. Interlock	X	NO	X	NO	X	X	X	X	X	NO
Power On-Off Facilities										
Emergency Pull Switch	NO	NO	NO	NO	X	NO	NO	X	NO	NO
Emergency Power Off	X	X	X	X	X	X	X	X	X	X
Element Master Power Off	X	NO	X	X	NO	X	X	X	X	X
Power On/Off	X	X	X	X	X	X	X	X	X	X
Power On Delay	X	NO	X	NO	X	X	X	NO	X	NO
Warning & Protection Facilities										
Thermal Warning	X	NO	X	X	*	X	X	X	X	X
Thermal Protection	X	*	X	X	*	X	X	X	X	X
Over Voltage/ Over Current Protection	X	*	X	*	*	X	X	X	X	X
Temporary Sustaining Power Source										
Prime Power Sensing	X	NO	NO	NO	NO	X	X	NO	X	NO
Battery Back-up Power Source	X	NO	NO	NO	NO	X	X	NO	X	NO
Duplex Power										
Duplex Power Supplies	NO	NO	NO	NO	X	NO	NO	X	NO	NO

Legend

X — Function provided as defined
* — Function provided - See note under standard definition
NO — Function not provided

control compartment of each system component. This switch is so constructed that, once activated, the services of maintenance personnel are required to restore power to the system.

Emergency Power-Off Function

This facility is activated by the EMERGENCY PULL switch at the SC or CC. It is operable whenever any element within the system has primary power present. Removal of power by this means may result in data loss. This switch must be used only in emergency situations.

Element Master Power-Off Function

This facility is activated by the ELEMENT MPO PULL switch at the element. Activating this switch causes all output power to be removed from circuits and cabling outside the power control compartment of that element, SCU, PAM, CC, or TCU. This switch is not interlocked by any other function. Removal of power by this means may result in data loss. Use of this switch must be restricted to emergency situations.

Power On/Off

This facility provides the normal means for the controlled application and removal of operating power. All power except control voltage and convenience outlets are under control of this facility.

The manual power-off function is inoperable when the element or unit (except SC and console portion of CC) is in other than state zero with the TEST switch enabled.

The power-on function, if active at the time of a prime power loss, is automatically restored upon the return of prime power.

Power-On Delay

A delay function, adjustable by maintenance personnel, over a range of 5 to 30 seconds, is provided which allows the setting of the individual element delays within the system to effect staggered element power-on sequencing.

Warning and Protection Facilities

Thermal Warning

A thermal sensing circuit is provided which determines when an element's or unit's internal temperature has reached a point approximately 10°F below the nominal thermal protection temperature. Actuation of this circuit (1) lights a THERMAL CHECK indicator on the element or unit, (2) lights the POWER CHECK indicator on the SC or CC, and (3) provides a marginal-condition interruption to the program.

Note: The SC and console portion of the CC light a THERMAL CHECK indicator upon sensing the thermal warning temperature. They do not generate an interruption condition.

Thermal Protection

A thermal sensing circuit is provided to determine when the element or unit internal temperature has reached the thermal protection temperature. Actuation of this circuit (1) causes a power-off function, (2) lights the element or unit THERMAL CHECK indicator and (3) lights the corresponding POWER CHECK indicator on the SC or CC. The power-off function causes an element-check interruption.

Note: The SC and console portion of the CC light a THERMAL CHECK indicator and sequences power down upon sensing a thermal protection temperature. They do not generate an element-check interruption. The DAU performs items 1, 2, and 3 above. It does not generate an element-check interruption.

Overvoltage/Overcurrent Protection

A sensing circuit is provided on the output of each dc power supply which determines when the supply output has reached a point predetermined for each element or unit above which further variation could cause circuit damage. When actuated, these sensing circuits:

1. Immediately suppress the output of the power supply whose sensing circuit has been actuated.
2. Sequence power off in the element or unit.
3. Light the element or unit POWER CHECK indicator.
4. Light a POWER CHECK indicator on the SC or CC.
5. Generate an element-check interruption.

Note: The SC and console portion of the CC perform items 1 through 4 above when they sense an overvoltage/overcurrent condition. They do not generate an interruption. The TCU, SCU, and DAU provide only overcurrent protection by means of circuit breakers on the input of each dc power supply.

Temporary Sustaining Power Source

Prime Power Sensing

A sensing circuit is provided on major elements to determine the loss of the prime power source. When the loss of prime power is detected, this circuit enables control circuitry to activate the battery backup power source. If prime power is restored at the end of the specified time, battery source will be deactivated. If prime power is not restored at the end of the specified time, a power-off sequence will be initiated. Emergency power off does not activate this circuit.

Battery Backup Power Source

Batteries are provided as a backup source to sustain the CE and IOCE power for a 6.5 ± 0.5 seconds and the SE and DE power for 5.5 ± 0.5 seconds. Recharging circuits are provided to maintain the battery charge at a specified level. The required recharge time to restore the battery after use is 300 times the period the batteries were in use.

On-Battery Timer

A timing device is energized when the battery backup power source is activated. If the battery backup source is still activated after a period of 6.5 ± 0.5 seconds*, this device causes a normal power-off function and deactivates the backup power source. This power-off function is not program interlocked and is operable in all element states.

Duplex Power Supplies

The SC and the console portion of the CC are each provided with two totally independent power supply facilities which are selectable by a single manual control. The switching controls are so designed that changing from one power facility to the other may be accomplished only by effecting a power-off function. The power controls and indicators are simplex, serving only the selected power supply facility. The CC has two additional simplex power supply facilities, one for each RCU in the CC.

SYSTEM POWER DISTRIBUTION

Each of the following system components receives 208V primary power individually from the installation power distribution system:

1. Computing Element (CE)
2. Input/Output Control Element (IOCE)
3. Storage Element (SE)
4. Display Element (DE)
5. Peripheral Adapter Module (PAM)
6. Tape Control Unit (TCU)
7. System Console (SC)
8. Configuration Console (CC)
9. Data Adapter Unit (DAU)
10. Storage Control Unit (SCU)

Each element and unit contains equipment to convert this primary power to voltages required for its own operation, and for the operation of attached IBM devices initially supplied with the system. Manual controls, protective circuits, and appropriate indicators are provided at each system component for the proper operation of its power equipment.

Power for some secondary units and devices is supplied by the primary unit to which they are attached; others are powered directly. The following text describes secondary device powering.

1052 Auxiliary and Console Printer Keyboards

1. 9020D System
   a. The auxiliary printer keyboards receive primary power from their own receptacles under control of the PAMs.
   b. The console printer keyboard receives all power from and under control of the SC.
2. 9020E System
   All printer keyboards receive power from and under control of their associated CE. Each 1052 has a POWER ON indicator to show the presence of power in the device.

2401 Tape Units

These devices receive power from and under control of the 2803 TCU. They do not have power-on indicators displayed, but will always have a control indicator on when power is being supplied.

2821 Control Unit

1. Console Switched Control Unit (9020D and 9020E): This control unit receives primary power from its own receptacle, but under control of the SC or CC, and supplies power to the 2540 Card Read/Punch and the 1403 Printer.
2. Independent Two-Channel Control Unit (9020D): This control unit has its own power source and supplies power to its associated 1403. The 1403 does not have a POWER ON indicator.

2312 and 2318 Disk Storage Units

These devices receive power from and under control of the 2314-A1 SCU. They do not have power-on indicators.

(*SE and DE timers are set to 5.5 ± 0.5 seconds).

SYSTEM POWER CONTROL FACILITIES

Power On/Off

- No system power on/off facility other than EPO is provided.
- Power sequences up automatically in each element following a loss in prime power.
- Elements sequence up over staggered time intervals to prevent a large load on prime power.

The IBM 9020D/E is designed for 24-hour operation, requiring that a minimum configuration of elements and units be operating at all times. Therefore, no system power on/ off facility (other than emergency power off) is furnished. Instead, individual element and unit power on/off facilities are provided for selective control of the power for the elements and units required for operation in specific situations.

The power on/off circuits for the elements and units have been designed as "latching" controls which remain in the power-on position even though prime system power is lost. Therefore, when prime power is restored following a power interruption, all elements and units which have their POWER ON switch in the ON position automatically initiate an internal power-on sequence. In addition, all system components (except for TCU, CC, SCU, and DAU) have each been provided with an adjustable time delay which will delay the start of its own internal power-on sequence following restoration of prime power. By adjusting this time delay in each element or unit to a value different from every other element or unit, a "system power-on sequence" can be established with the TCUs, CC, SCUs, and DAUs powering-on immediately, followed by the other elements or units spaced over a delay range of 5 seconds minimum to 30 seconds maximum.

If a power loss is less than the preset on-battery value, the battery backup system in the CEs, IOCEs, SEs, and DEs sustains these elements in an uninterrupted power-on status, leaving only the TCUs, SCUs, SC or CC, and DAUs or PAMs to be cycled back up.

Emergency Power Off (EPO)

- EPO removes power from entire system.
- MPO removes power from an individual element.
- Three wires from each element provide complete interlocking.
- Any element can pick EPO contactor in SC or CC.

Operation of the EPO power interlock circuitry requires a +24V dc control voltage. This +24V is available within each element even though normal power is off in that element (including EPO/MPO conditions). This voltage is not available when the facility supply is open into that element or when the mainline CB in the element is open.

The EPO contactor within the system or configuration console must be picked before any element power (including the console) can be sequenced up. The EPO contactor (Figure 1-1) can be picked by a +24V dc control voltage from any system element, provided the two EPO switches are closed. The console power supply is not needed for picking the contactor; the system or configuration console may be temporarily out of operation without impairing operation of the remainder of the system.

The pick (and hold) circuit for the EPO contactor in the console is from the +24V supply in any element, through an isolation diode (which prevents the +24V from one element feeding back into another), and to a common +24V terminal connection in the console. From this common terminal which is connected to the +24V supplies of all system elements, the circuit continues through the console EPO switch to the EPO contactor coil, and back through the common 24V return. Any or all system elements, therefore, may be energizing the EPO contactor.

When the EPO contactor points close in the console, a circuit is established (Figure 1-1) to pick an MPO contactor in each element. This circuit is from the +24V control voltage, through the element MPO switch and MPO contactor coil, and to a second but different common +24 terminal in the console. From this common terminal which connects the MPO circuitry for each element, the circuit is completed through three EPO points in parallel and to the common 24V return. With element MPO contactor points closed, +24V dc is supplied to the power control circuitry in the element to start power-on sequencing.

A contactor (K1) in the battery package of the major elements is picked and held in parallel with the element MPO contactor. Therefore, K1 drops under MPO/EPO conditions and prevents battery power from feeding into the power circuitry.

POWER MONITORING FACILITIES

- Provision for monitoring by operator and by control program.
- Indicators for monitoring by operator.
- Program interruptions for monitoring by control program.

Facilities are provided in the 9020D/E systems for monitoring the status of power both by the operator and by the

control program. Indicators are provided to make the operator aware of the status of system power. Critical indicators on the individual elements are augmented by indicators on the system or configuration console.

Provision is also made to automatically interrupt the control program when a discrepancy in system power occurs.

Element Indicators, Local

Table 1-2 lists the indicators of system significance located on the various system components. The descriptions that follow are applicable to each component as indicated in the table.

Power-On Indicators

MAIN LINE ON Indicator: Is on when prime power is available from the power control compartment. Prime power is not available when EMERGENCY PULL or ELEMENT MPO PULL have operated.

SEQUENCE COMPLETE Indicator: Is on when all operating voltages are present in an element or unit.

Environmental Check Indicators

THERMAL CHECK Indicator(s): One or more indicators are provided to indicate when the internal temperature has reached the thermal warning level. The indicator(s) are turned off by activating the THERMAL CHECK RESET pushbutton if the temperature has fallen below the warning level.

POWER CHECK Indicator: Lights when a power-off condition exists whether from a functional or a protective cause.

Battery

ON BATTERY Indicator: Is on when the element is operating from the battery backup power source..

System Indicators

Tables 1-3 and 1-4 list the system indicators displayed at the SC and CC. The descriptions that follow are applicable to the components indicated in these tables.

POWER CHECK Indicators: These indicators parallel those displayed on the individual element or unit. In addition, they are also used to display thermal check conditions.

Note: The SC and CC provide their own POWER CHECK indicators and have separate THERMAL CHECK indicators. The DAU does not have a local POWER CHECK indicator.

BATTERY Indicator: This is a single indicator shared by elements having battery backup power sources. It is lit when one or more of the BATTERY indicators on the individual elements are lighted.

STANDBY Indicator: Is on when the prime power for the system is being provided by a standby power source: e.g., motor generator. The source of this indication is a contact closure external to the 9020 system.

Program Interruption Facilities

Table 1-5 lists the program interruptions resulting from power discrepancies and indicates the system components which provide the interruptions.

Catastrophic Condition Indication

Element Check (ELC): A power-off condition whether from a normal functional cause or the result of protective circuit action causes an ELC interruption.

Marginal Condition Indication

Out-of-Tolerance Check (OTC): An element sensing a thermal warning condition causes an OTC interruption.

Note: A thermal warning in the SE or DE causes an ELC interruption and sets a bit in the logout word which indicates checks. No OTC interruption is generated.

A thermal warning in the CC causes an ELC interruption and sets a sense bit which indicates OTC checks. No OTC interruption is generated.

Attention Status: A unit sensing a thermal warning condition indicates the marginal condition through the I/O interface by setting the attention bit in the status byte. No OTC interruption is generated.

Note: The PAM also sets a unique bit in a sense byte to distinguish this attention condition from others that might occur from normal operations. A pushbutton is provided to simulate the condition for testing.

On-Battery Indication

On-Battery Signal (OBS): The element causes an interruption to indicate that it is operating from its battery backup power source.

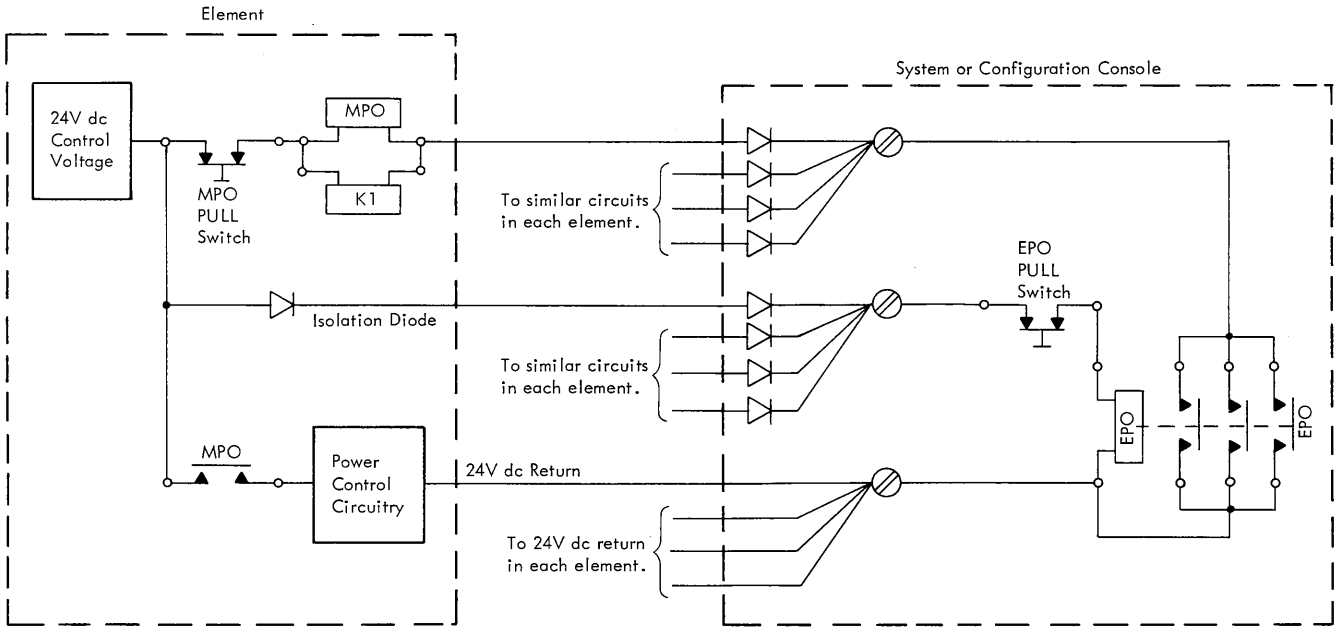


Figure 1-1. EPO Power Interlock (Element to Console)

Table 1-2. Local Element Indicators

Local Indicators	System Component									
	IOCE 7231 -2	PAM 7289 -2	TCU 2803 -1	SC 7265 -2	SE 7251 -9	CE 7201 -2	CC 7265 -3	DE 7289 -4	DAU 2701	SCU 2314 -A1
Power Indicators										
Main Line On	X	X	X	X	X	X	X	X	X	X
Sequence Complete	X	X	X	X	X	X	X	X	NO	X
Environmental Check Indicators										
Thermal Check	X	X	X	X	X	X	X	X	X	X
Power Check	X	X	X	X	X	X	X	X	NO	X
Battery										
On Battery	X	NO	NO	NO	X	X	NO	X	NO	NO

Legend: X — Function provided as defined
NO — Function not provided

Table 1-3. System Indicators 9020D

System Console	Source							
	CE 7201-2	IOCE 7231-1	SE 7251-9	PAM 7289-2	TCU 2803-1	SC 7265-2	External	SCU 2314-A1
Indicators								
Power Check	X	X	X	X	X	*	NO	X
Battery	X	X	X	NO	NO	NO	NO	NO
Standby	NO	NO	NO	NO	NO	NO	X	NO

Legend: X — Function provided as defined
NO — Function not provided
* — Function provided - see special definition

Table 1-4. System Indicators 9020E

Configuration Console	Source									
	CE 7201 -2	IOCE 7231 -2	SE 7251 -9	DE 7289 -4	TCU 2803 -1	CC 7265 -3	DAU 2701	DG	RKM	External
Indicators										
Power Check	X	X	X	X	X	*	X	X	X	NO
Battery	X	X	X	X	NO	NO	NO	NO	NO	NO
Standby	NO	NO	NO	NO	NO	NO	NO	NO	NO	X

Legend: X - Function provided as defined
* - Function provided - see special definition
NO - Function not provided
DG - Display Generator
RKM - Radar Keyboard Multiplexer

Table 1-5. Program Interruptions Resulting from System Power

Power System Interruptions	Source									
	IOCE 7231 -2	PAM 7289 -2	TCU 2803 -1	SC 7265 -2	SE 7251 -9	CE 7201 -2	DE 7289 -3	CC 7265 -3	DAU 2701	SCU 2314 -A1
Catastrophic Condition										
Element Check ELC)	X	X	X	NO	X	X	X	X	NO	X
Marginal Condition										
Out of Tolerance Check (OTC)	X	NO	NO	NO	X	X	X	X	NO	X
Attention Status	NO	*	X	NO	NO	NO	NO	NO	NO	X
On Battery										
On Battery Signal (OBS)	X	NO	NO	NO	X	X	X	NO	NO	NO

Legend: X — Function provided as defined
* — Function provided - see special definition
NO — Function not provided

Note: An on-battery condition in an SE or DE causes an ELC interruption and sets a bit in the logout word which indicates checks. No OBS signal is generated. A pushbutton is provided at the CE, IOCE, DE, and SE to simulate the condition for testing.

ELEMENT POWER EQUIPMENT

The power equipment in major 9020D/E elements contains four major sections:

1. Power control and sequencing, which provides input power control protection and distribution and also satisfies power sequencing required within the element.
2. Converter/inverter (C/I), which converts 60-Hz, 3-phase, 208V ac input power to single-phase, square-wave, 2500-Hz power.
3. DC regulators, which convert the 2500-Hz power to regulated dc power as required in the element or unit.
4. Battery backup system, which keeps the C/I running for a period of time if an input line failure occurs.

Power Control and Sequencing

The control and sequencing section is unique in detail to each element. Its function is to control the distribution of prime power, to protect circuits using this power, and to sequence the application of power as required by the individual circuits.

Application of prime power to an element (Figure 1-2) brings up that element's prime dc control voltage supply. The output of this supply is connected to the EPO (emergency power off) circuit in the SC or CC. If the EPO switch is closed, a contactor in the console will pick, providing a return for the EPO circuit within each element.

At the element, the MPO (master power off) switch, when closed, will pick the element MPO contactor which will then apply 208V ac to the convenience outlet transformer and the prime control voltage supply. It also applies dc control voltage to the sequence and control relays.

Closing the POWER ON/OFF switch starts a time delay. This delay is adjustable from 5 to 30 seconds and is set to a value to obtain a staggered power-on sequence of the various system elements. At the end of this time delay, the ac-on contactor applies 208V ac to the blowers, C/I, and the battery charger.

The output of the C/I is distributed to the dc regulators and to the bootstrap supplies. When these supplies come up, the control voltage loads are switched from the prime control voltage supplies to the bootstrap supplies. The ac/on contactor is still fed from the prime dc supply.

When all the standard dc voltages are up, contacts apply the C/I output to the special voltage regulators. When the special dc voltages are up, contacts turn on the SEQUENCE COMPLETE indicator and generate a 'power-on reset' signal to the logic circuitry.

A prime power loss is detected by the line sense circuitry, which switches in the battery source. It also starts a timer which times out for the pre-adjusted time interval.

If prime power is restored before the preset time interval has elapsed, the battery source is switched out. If prime power does not return, the timer sequences power down.

A catastrophic thermal or overvoltage/overcurrent (OV/OC) condition also causes a power-down sequence.

Converter/Inverter

A block diagram of the converter/inverter (C/I) is shown in Figure 1-3. The 3-phase, 208V ac line voltage is fed through RFI (radio frequency interference) filters which filter conducted line noise. The voltage is then rectified and peak-filtered by means of a capacitor filter to produce the dc voltage which is used as an input to the inverter circuit. In the case of a prime power failure, this dc voltage is supplied from a backup battery source.

The inverter circuit is a parallel SCR (silicon-controlled rectifier) circuit which produces a 2500-Hz square-wave output having an RMS value of approximately one-half the dc input to the circuit. The frequency of this output is established by a 2500-Hz clock signal fed to the inverter circuit. This clock signal is provided by an oscillator circuit which takes one phase of the line voltage, transforms it to a lower voltage (28V ac) and feeds it into the C/I where it is then rectified, filtered, and regulated. The regulated dc is then used in a magnetic oscillator whose multiple outputs are formed and sent to the inverter circui SCRs.

To maintain the output of the C/I in the case of a prime power failure (dc input to the inverter being supplied by the battery backup source), a bootstrap supply is connected to the output. This supply steps the output down and applies it to the oscillator circuit as an alternate 28V ac source, thus maintaining its operation.

The rectifiers and filter in the oscillator circuit in the C/I also provide a 25V dc unregulated output for use as a bias voltage in the dc regulators.

The 25-amp C/I is used in the SC while the 75-amp C/I is used in the CE, SE, DE, IOCE, and PAM units.

DC Regulators

The dc regulators (Figure 1-4) are time-ratio controlled circuits. The regulators sense 2500-Hz C/I output with an input transformer to provide isolation as well as voltage transformation. The square-wave output of this transformer is then rectified and fed to a blocking circuit. The square wave is also fed to an amplifier circuit to establish the

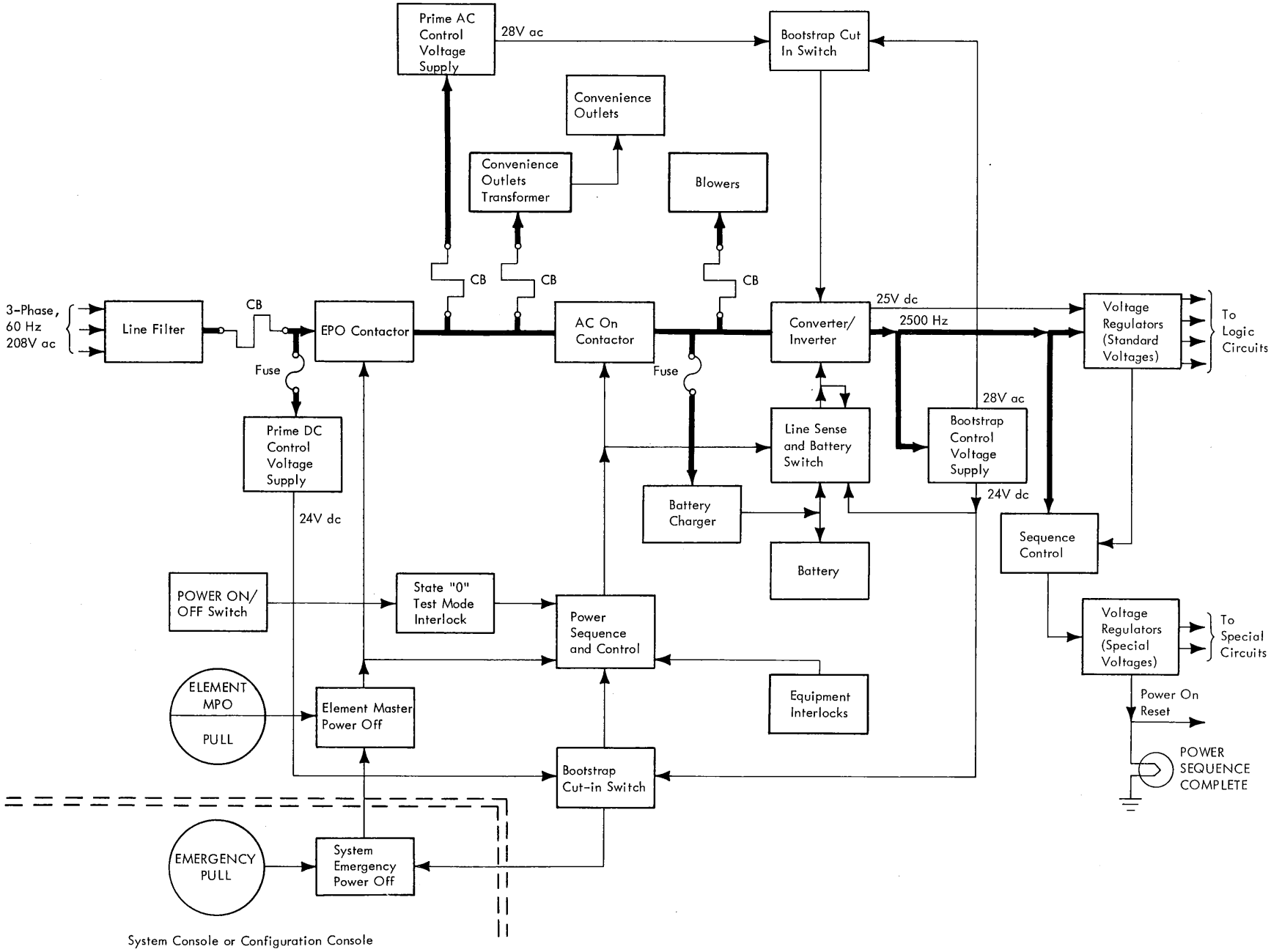


Figure 1-2. Typical Element Power Control, 9020D/E System

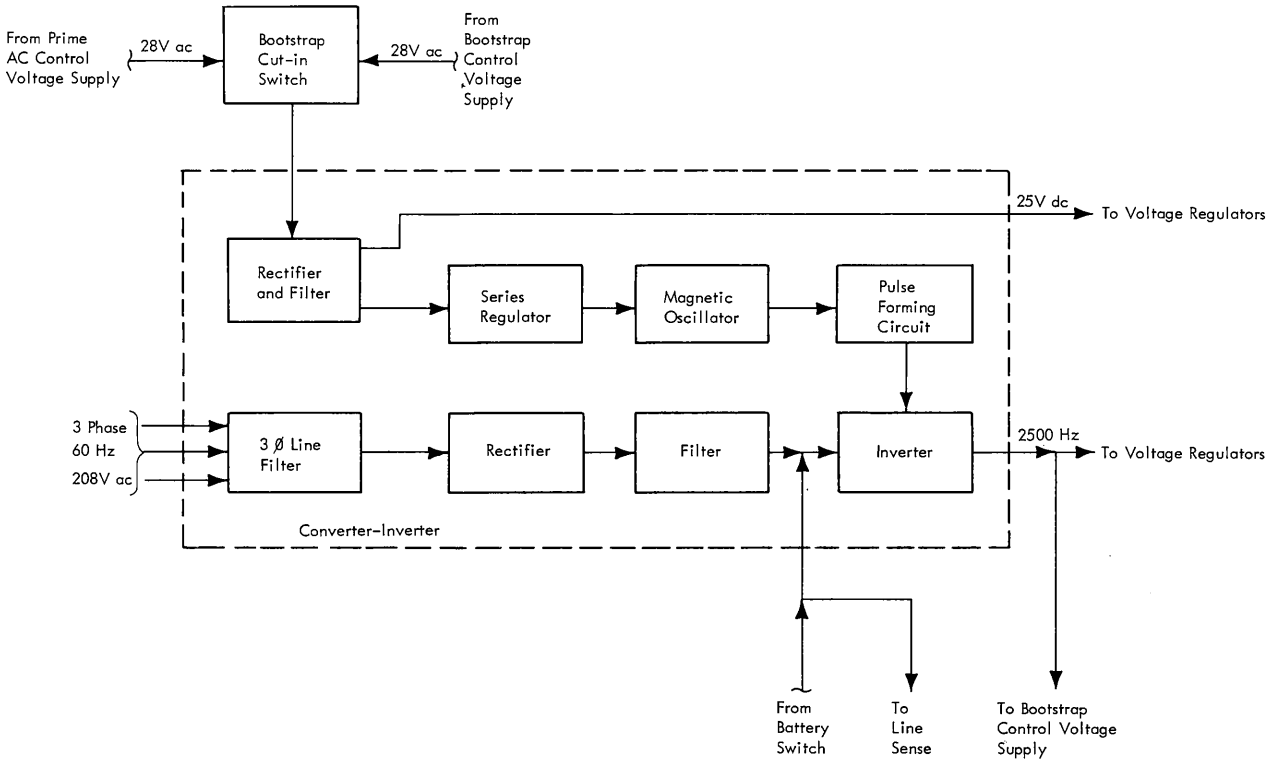


Figure 1-3. Converter/Inverter

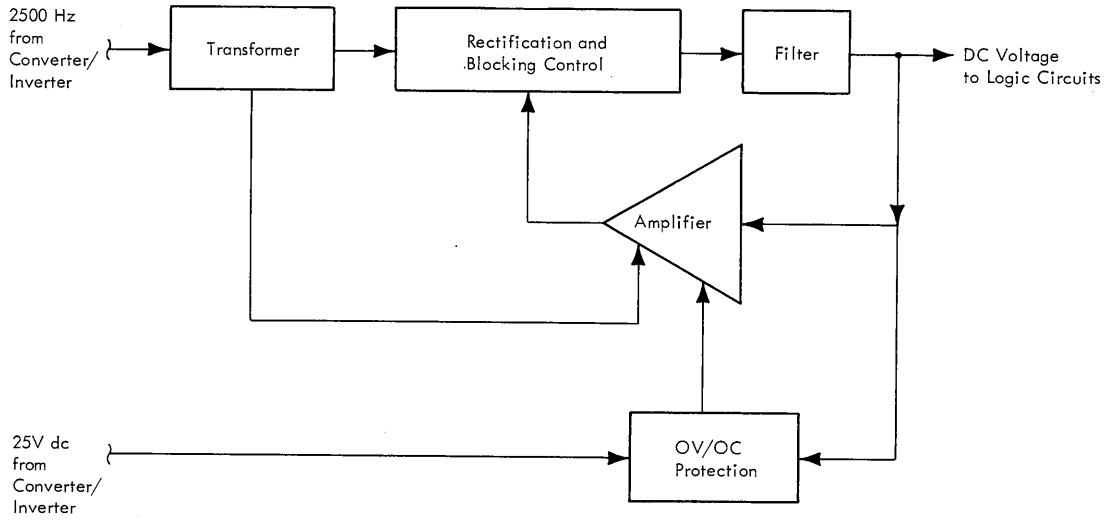


Figure 1-4. DC Regulator

switching cycle frequency (5000 Hz) of the blocking circuit. This amplifier also monitors the dc output of the regulator, compares it to a reference, and establishes the duration of the blocking action in each switching cycle of the blocking circuit. Thus, the blocking circuit output is a 5000-Hz pulse train with feedback regulated pulse duration which, when averaged by the filter, provides the desired dc output voltage.

To protect the dc regulators and the loads which they feed, a circuit is provided which monitors the output current and voltage. Should either exceed an upper limit, a short circuit is placed on the output, the regulator shuts off, and the sequence and control circuitry is signalled to sequence power down.

Battery Backup Power

Battery backup power equipment is contained in the CE, IOCE, SE, and DE to permit the program to continue to a logical stopping point in case of loss of main power.

Battery backup equipment and circuit operation is explained in detail later in this chapter.

WARNING, PROTECTION, AND CHECKING FACILITIES

Protection and checking circuits are provided in the 9020 system to prevent equipment damage and to simplify maintenance. During normal system operation, the protection circuits operate in conjunction with the control circuits to apply power sequentially to the circuits. If a malfunction (e.g., overvoltage or thermal) occurs, the protection circuit starts a power-off sequence. Special considerations have been made to ensure that storage voltages are removed immediately when any malfunction occurs.

Checking circuits allow maintenance personnel to detect marginally functioning circuits before they become a catastrophic failure.

Emergency Power Off (EPO)

- An EPO switch is at SC or CC.
- Operation of EPO switch causes all system elements to sequence power down immediately.
- An element power-on sequence cannot be started when system is in an EPO state.

A red EMERGENCY PULL (EPO) switch protects the system and personnel in emergency situations by enabling operating personnel to remove power immediately from all system components. This EPO switch is at the SC in a 9020D system or the CC in a 9020E system. The switch is interlocked mechanically so that it remains in the off (pulled) position until reset manually.

Overvoltage/Overcurrent Protection

- Each CE, IOCE, SE, DE, SC, CC, and SCU contains OV/OC protection.
- Each TCU and DAU contains overcurrent protection.
- An OV/OC condition causes that element to sequence power down.
- A remote SCR shorts regulator output to ground.

All 9020 system elements except the TCU, SCU, and DAU use the same type of OV/OC protection circuit. If an OV/OC condition occurs in a given regulator, its respective OV/OC protect circuit shorts the regulator output to ground and starts a power-down sequence in the element control circuitry.

A typical OV/OC protection circuit for the dc regulators in an elment is shown on Figure 1-5. Basically, this circuit includes an OV/OC assembly on an SMS card, and an axe assembly that connects across the output bus of the regulator.

Current is sensed by a current transformer in the regulator control circuit whose output is applied to a differential amplifier in the sense section of the OV/OC SMS card. When the maximum voltage or current limit is exceeded, the differential amplifier is turned on. It gates the SCR in the axe assembly into conduction, and picks the reed relay on the OV/OC SMS card. When the SCR on the axe assembly conducts, it shorts the regulator output to ground to prevent damage to the circuits which that regulator powers. When the reed relay picks, one set of RR-1 contacts shorts out the control winding of the magnetic amplifier in the regulator control circuit, one set of contacts energizes the reed relay hold coil and lights the OV/OC indicator with +25V dc regulator bias from the C/I, and one set of contacts is used to start a power-down sequence in the element control circuitry. The OV/OC indicator is used to visually determine which dc regulator in the element had the OV/OC condition.

One set of N/O contacts of the OV/OC sense relay (Figure 1-5) is used by the element to initiate a power-down sequence. The CE power-down control circuitry is shown in this figure as an example of how an OV/OC condition can sequence power down in an element.

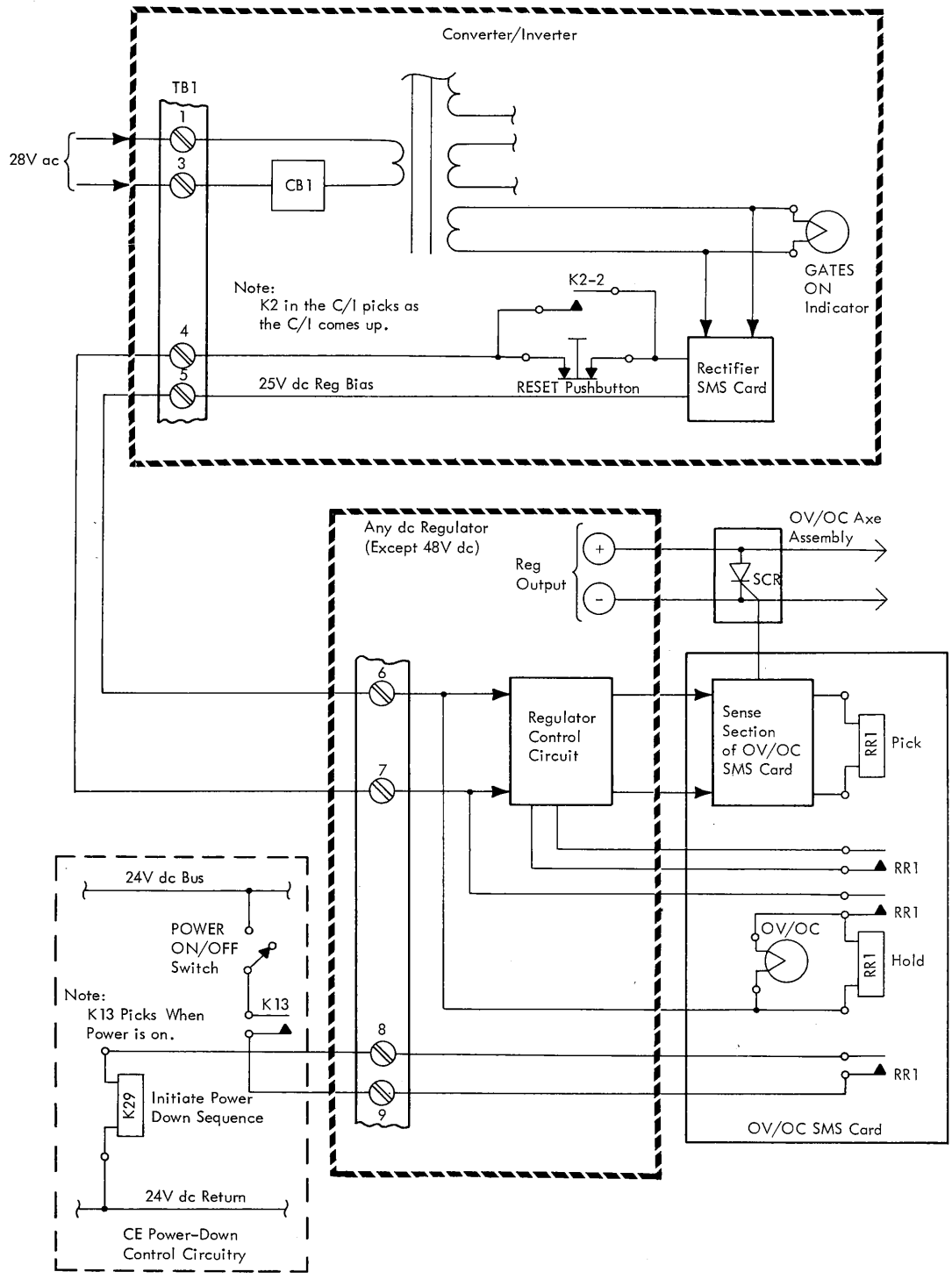


Figure 1-5. Regulator OV/OC Circuitry

To restore power to an element, the OV/OC condition must be reset manually at the C/I, and, on some elements, the POWER ON/OFF switch must first be turned off and then on.

Pressing RESET at the C/I opens the +25V dc bias line to the dc regulators, which drops the reed relay and turns off the indicator on the OV/OC SMS card. When the reed relay drops, it allows the control winding of the magnetic amplifier to function, and opens the circuit which started the power-down sequence. Power can now be sequenced up.

The K2-2 points, in parallel with the RESET pushbutton in the C/I, prevent opening of the +25V dc bias line to the regulators in case RESET is accidentally pressed while power is up normally in an element. K2 in the C/I picks as power comes up in the C/I.

If the OV/OC condition has not been reset, when the POWER ON/OFF switch is turned back on, the OV/OC reed relay N/O points prevent a power-on sequence.

In all cases of OV/OC, the line sense and switching circuit is deconditioned by picking K53 (disarm line sense) and dropping K52 (arm SCR gate) and K54 (arm SCR anode), thereby preventing the battery backup supply from sustaining power for an additional period of time.

Note: When RESET is pressed at the C/I, hold it for a few seconds. A momentary depression is not enough time to reset the OV/OC reed relay and gives a false impression of a second OV/OC condition.

The TCU and DAU provide only overcurrent protection for their regulators. This protection is with circuit breakers within their power supply assemblies. A fault or overload in any regulator causes its associated circuit breaker to trip, which opens an auxiliary side-switch contact on the circuit breaker. When this side-switch contact opens, it causes a power-off sequence within either the TCU or DAU.

Undervoltage Protection

- Several types of undervoltage detect circuits are used in 9020 system elements.
- Undervoltage protection sequences power off.

The undervoltage sense systems are designed to protect circuit and core storage components by sequencing power off in an element when a voltage tested by the undervoltage sense circuit in that element falls below a prescribed limit. Individual elements each have their own distinctive types of undervoltage check circuits. These circuits are explained in later chapters which deal with the respective elements.

Thermal Protection

- Both low- and high-limit detection.
- Low-limit thermals provide an OTC signal to system program.
- High-limit thermals cause a power-off sequence in that element.
- Either thermal condition causes a power check indication at SC.

Each 9020 system element contains thermal sensing devices which check high- and low-element operating temperatures.

When the low temperature limit in an element is exceeded, a THERMAL CHECK indicator on that element is turned on and a POWER CHECK indicator on the SC or CC is turned on. The console has a separate POWER CHECK indicator for each system element. Exceeding the lower thermal limit in an element is considered a thermal warning condition, and an out-of-tolerance check (OTC) signal is sent from that element to all CEs to alert the control program for possible system reconfiguration before the high thermal limit is reached.

Exceeding the high thermal limit in an element is considered a catastrophic condition and power in that element is immediately sequenced down. Under these conditions, the battery supply in that element is prevented from sustaining its power for an additional period of time. Battery backup is not necessary for a thermal condition because the system control program should have already configured this element out of the ATC subsystem when the OTC signal (thermal check) was sent to all CEs.

The thermal indicators on an element with a thermal condition remain on as a visual indication of the trouble area in that element. These indicators can be turned off by pressing the THERMAL RESET pushbutton in the element after the temperature in the trouble area has returned to normal.

Regulator Output Sensing

- Local sensing.
- Remote sensing.
- Thermistor sensing.

Three types of regulator output sensing are used in the 9020 system: local, remote, and thermistor. In local and remote sensing, the regulator output is fed back to the input of a differential amplifier (Figure 1-6). The output of the differential amplifier controls the operation of the

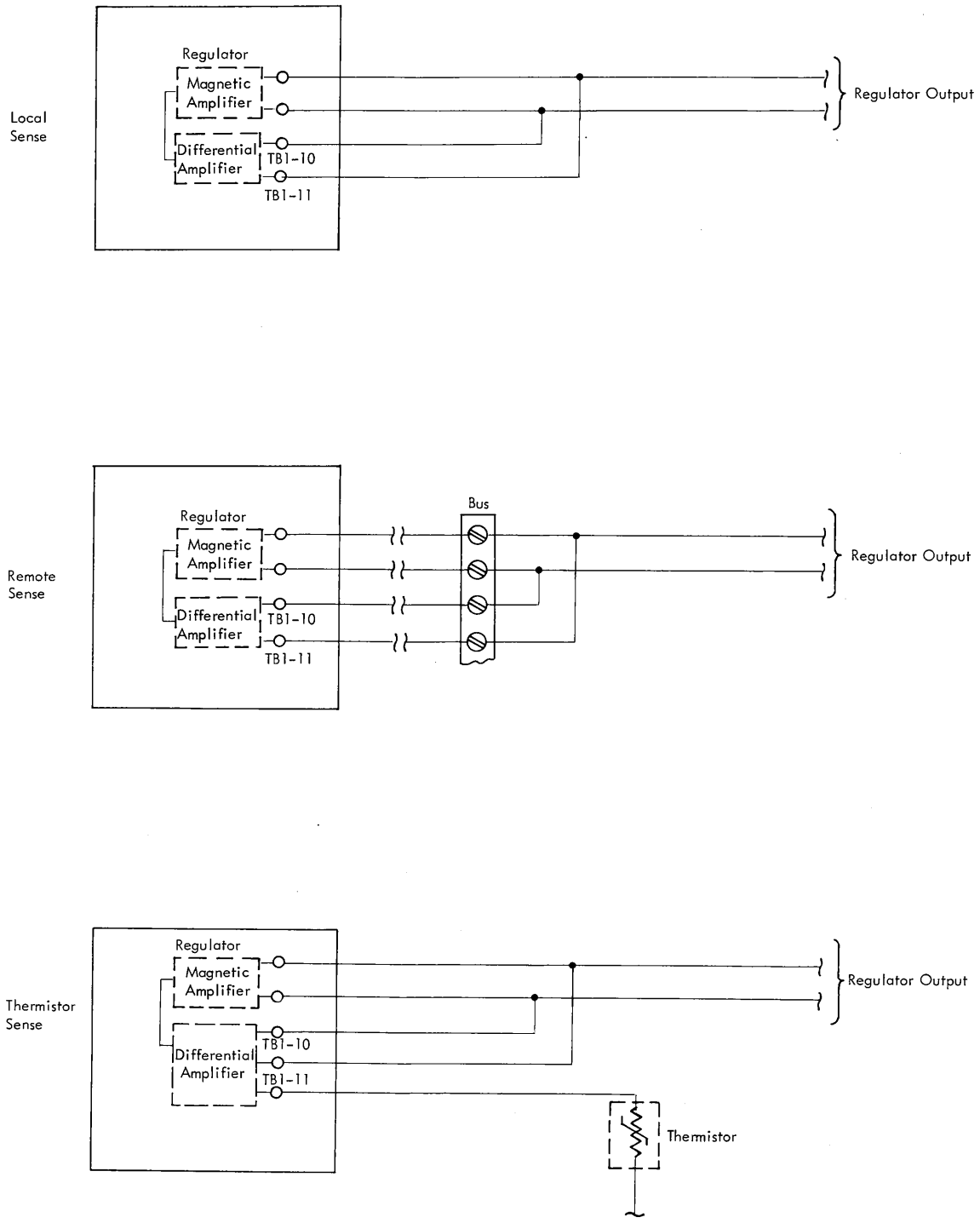


Figure 1-6. Regulator Output Sensing

regulator magnetic amplifier to produce the regulator output. An increase in the regulator output causes the differential amplifier to produce a higher output which decreases the output of the magnetic amplifier. Similarly, a decrease in the regulator output causes a decrease in the differential amplifier output.

Thermistor sensing is used in the IOCE +60V and +56V regulators. If the array temperature increases, the thermistor resistance decreases, causing a higher differential amplifier output. This condition decreases the magnetic amplifier output (regulator output) until the array temperature decreases.

Marginal Checking

- Is a periodic preventive maintenance technique.
- Detects marginal operation of voltage sensitive circuits.

Marginal checking is a technique used to detect the marginal operation of the voltage sensitive circuits in the system. These circuits have nominal values of voltage and current at which they are designed to function. Each circuit operates within certain margins (regulator output above and below the nominal rating). However, aging and other factors may cause a gradual deterioration in the operating characteristics of the circuits. By raising and lowering the regulator voltage within the design margins, it is possible to inspect all circuits that are powered by that voltage. On the basis of this inspection, any component that approaches a failure condition may be replaced. This type of check is made periodically as a preventive maintenance technique. System downtime and many troubles can be avoided by using marginal checking to make failure less intermittent and more recognizable.

All the system elements, except the DAU, SCU, and TCU, have similar marginal checking circuits. Each marginal check voltage has an associated control potentiometer mounted on its respective element control panel. An indicator is turned on when a control is adjusted from its center position. Each control is independent and adjusts only one regulator.

Figure 1-7 shows a typical +6V marginal check circuit. Because all circuits operate in a similar manner, only the typical circuit is described.

Note: In the SC, the marginal select switch is not required because the +6V line is the only item that is marginally checked. The meter shunt (R1) is not required in the PAM or SC because only one voltage (+6V) is marginally checked.

The regulator output is monitored at the logic gate to ensure that the voltage monitored is the circuit input voltage. Monitoring at the logic gate prevents an erroneous circuit input caused by voltage drop in the power distribution cable. The marginal voltage adjustment potentiometer is connected to the amplifier portion of the regulator. The potentiometer is used to change the input bias level of the amplifier, varying the regulator output.

When the potentiometer is positioned from the center point, switch S1 turns on the margin-applied indicator. An indicator shows when a voltage is adjusted away from its nominal value.

In the CE, IOCE, and PAM, the meter is connected to the circuit checked by the MARGINAL VOLTAGE SELECT switch. In the SC the meter is connected directly to the +6V line. In the DAU, SCU, and TCU, marginable supplies must be monitored with an external meter during marginal testing.

Voltage Monitoring

- The CE, IOCE, PAM, CC, and SC contain meters to monitor internal voltages.
- All meters are selected by rotary switch.

Some of the elements (CE, IOCE, PAM, CC, and SC) in the 9020 D/E system contain meters which are used to monitor various internal voltages. The voltage to be monitored by the meters is selected by rotary select switches.

The IOCE meter can monitor any of its regulators. The meter is selected by one of two rotary switches which are electrically interlocked to prevent two voltages from being simultaneously applied to the meter. The marginal supplies are selected by one of the rotary switches; the non-marginal supplies, by the other.

The CC meter can monitor any of its regulators. The regulator is selected by a rotary select switch.

The CE, SC, and PAM meters can be switched to any of their supplies which can be marginally checked. These are the only supplies on these elements which can be checked on their meters. The SC can only monitor one of its two 6V marginal supplies on the meter at one time, depending upon which one of its two power supplies it is operating on.

BATTERY BACKUP POWER FACILITIES

General

- Each CE, IOCE, DE and SE contains a battery backup supply.
- The element automatically switches to battery supply without interrupting system operation.

- All power is removed if prime power is not restored within approximately 5.5 seconds (SE and DE) or 6.5 seconds (CE and IOCE) of battery operation.

- Batteries are not applied under EPO/MPO conditions.

- Loss of prime power and use of battery power is indicated to system program.

Each CE, IOCE, DE, and SE contains a battery backup power source that permits uninterrupted power for approximately 5.5 seconds (SE or DE) or 6.5 seconds (CE or IOCE), following the loss of the 208V ac primary input power.

Loss of primary 208V ac power is sensed by the line sense and switching circuit as a decay of the voltage on the converter dc bus to the inverter. When this voltage drops below a preset limit (240V dc), RR1 in the line sense unit picks and fires an already conditioned SCR in the line sense and switching circuit. This SCR feeds battery power to the dc bus which goes from the converter section to the inverter section of the C/I (Figure 1-8). This high-speed switching occurs without interruption to the 137V ac, 2500-Hz, C/I output.

Note: Battery power is not applied during an EPO or MPO condition because the coil of contactor K1 (Figure 1-9) in the battery package is in parallel with the coil of the MPO contactor, and the N/O contacts of K1 are in the output circuit of the battery supply.

Figure 1-10 shows the interconnections within a battery package for any element.

After 5.5 seconds (SE or DE) or 6.5 seconds (CE or IOCE) of battery operation, power is sequenced down by removing the input to the high dc (ROS and storage) voltage supplies. At the time that power is removed from the low voltage dc supplies (logic voltages), the contactors within the line sense and switching circuit are dropped and the SCR is cut off to open the battery circuit.

When an element switches to battery power, an OBS signal is sent to all CEs within the system so that the monitor program is continually alert to the power status of each CE, IOCE, DE, and SE. Battery indicators on the SC or CC and on the individual elements reflect the current source of power.

If prime power returns to the system before the battery timeout period, the power supply automatically switches back to prime power with no loss of operation.

During the time that primary input power is active, a current-regulated battery charger circuit supplies a recharge current to recover and maintain the battery package charge.

DANGER

Battery voltage is present inside the charger assembly until switches are turned off on the battery assembly and/or EPO contactor coil voltage is removed.

The full dc potential of the batteries is available across the red and black binding posts on the metal power control box inside the battery cabinet when both battery switches are on and +24V dc is applied to the EPO contactor coil. This voltage ranges from 300 to 350V dc and can result in electrical shock. Interrupting the +24V dc from the contactor coil removes the battery potential from the binding posts. If J1 is connected and the charger is active, full charger potential is present (450 to 500V dc) at the binding posts even when the battery switches and contactor are inactive.

Voltage inside a battery pack may be as high as 160V, so be careful that a tool does not short across battery terminals. A tool can be thrown with damaging force. Specific safety information and maintenance procedures are in the maintenance manual for the 7201. These procedures describe the positioning of the three safety covers so that only one tray is exposed, and the removal of links between trays 2-9 and 6-13 to reduce tray voltage.

Battery Backup Circuits

The battery backup power equipment comprises four assemblies: the battery package, the battery charger, the bootstrap power supply, and the line sense and switching circuitry. Each is explained in the following text.

Battery Package

- Two packs of nickel cadmium cells.

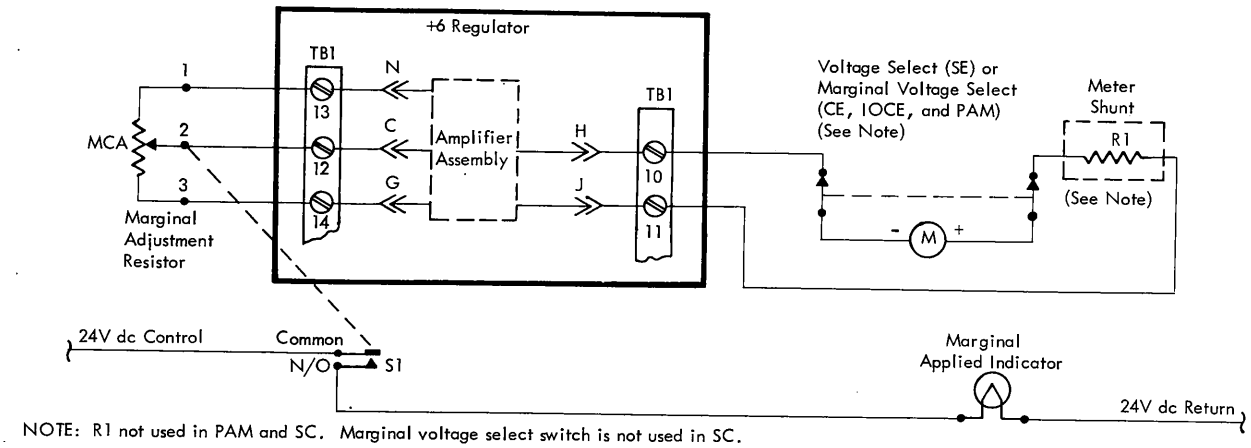
- A total of 260 1.25V cells connected in series.

- Output from battery package is controlled by EPO/MPO switches.

A battery package includes two packs of nickel cadmium cells that are connected in series to provide a no-load potential of 315V. (With the battery charger on the batteries fully charged, the voltage can be approximately 340V.)

Each pack contains 13 cell trays, each containing ten 1.25V cells. A specific amount of active primary ac time must be allowed for battery recharge after each battery package usage. The recharge time is equal to the battery-package operate time multiplied by 300.

The battery package also contains a contactor (K1) which must be picked before the battery power source can



NOTE: R1 not used in PAM and SC. Marginal voltage select switch is not used in SC.

Figure 1-7. +6V dc Marginal Check Circuit

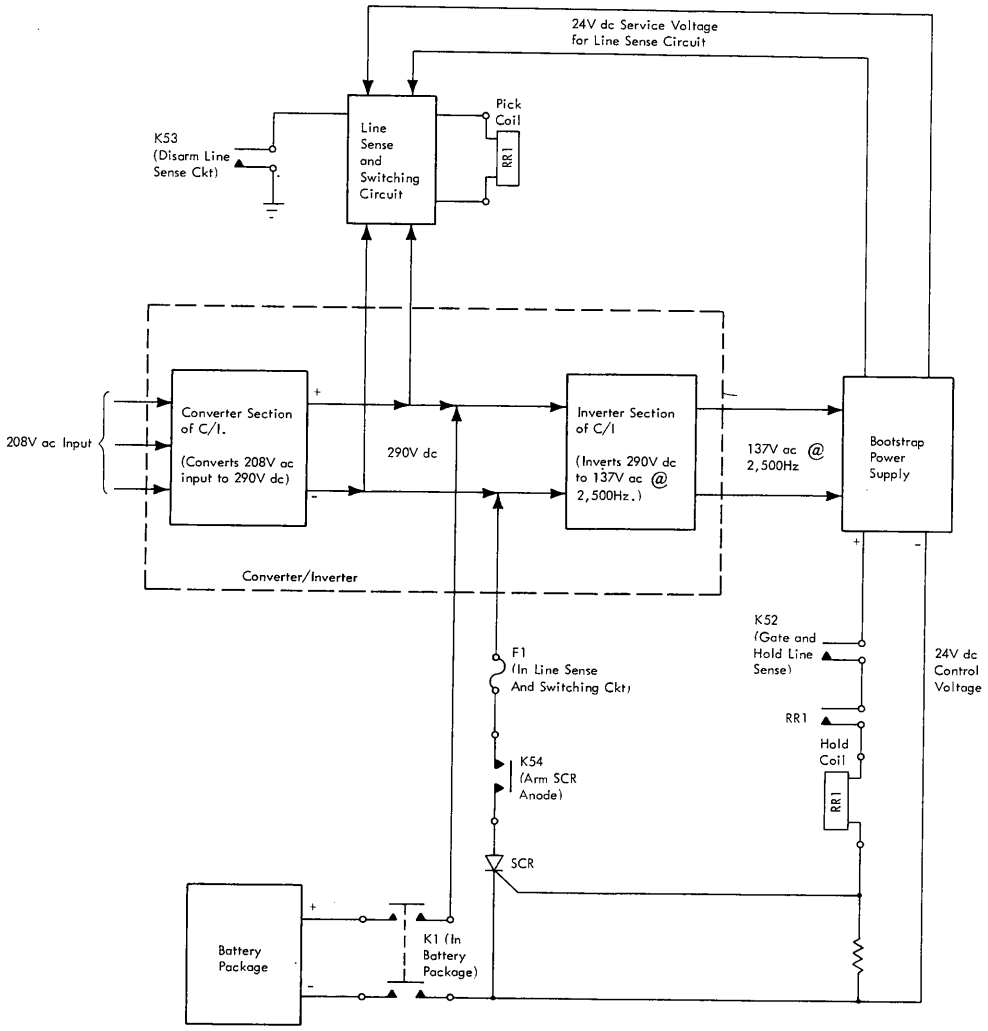


Figure 1-8. Battery Backup

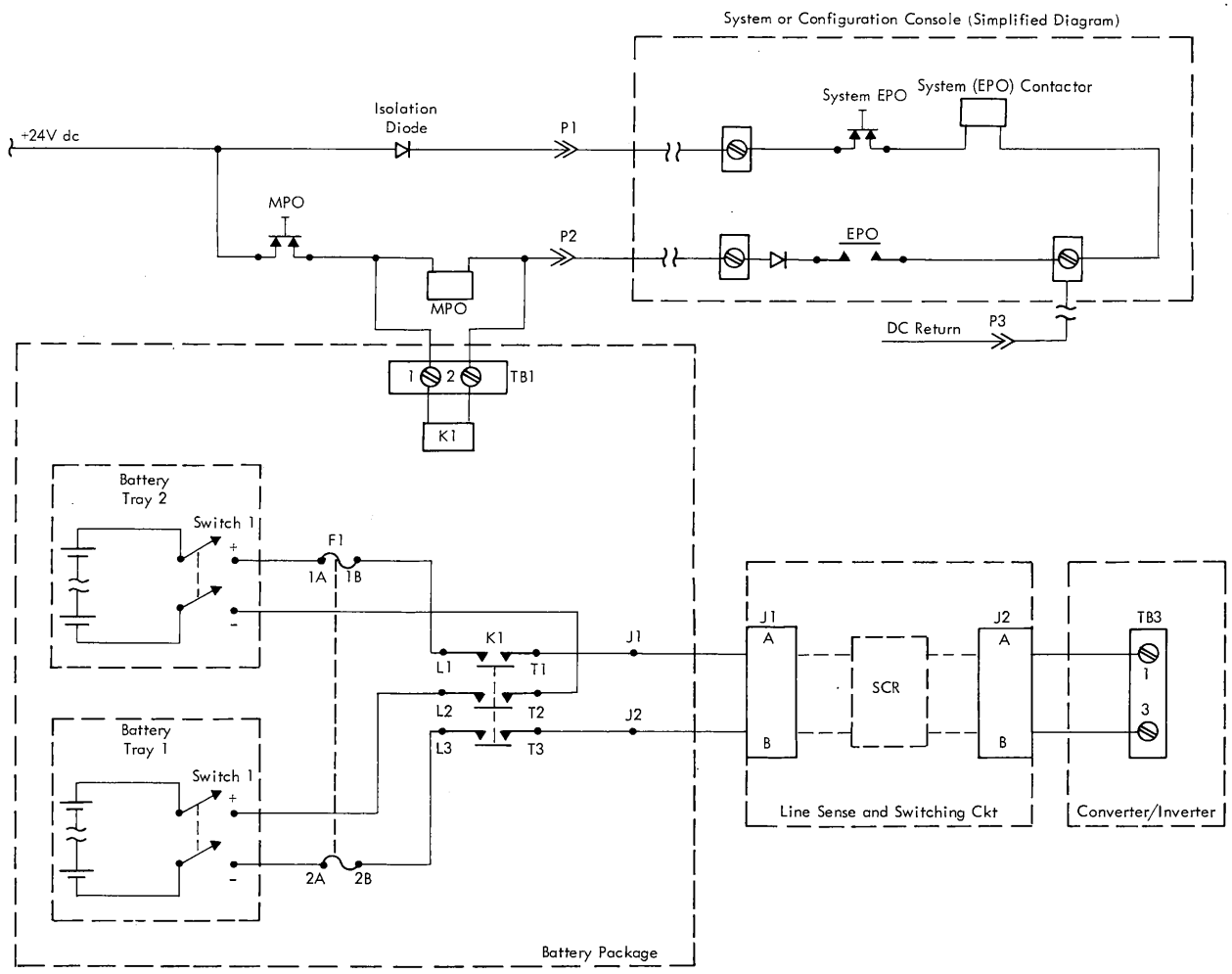


Figure 1-9. Battery Package Tie-In

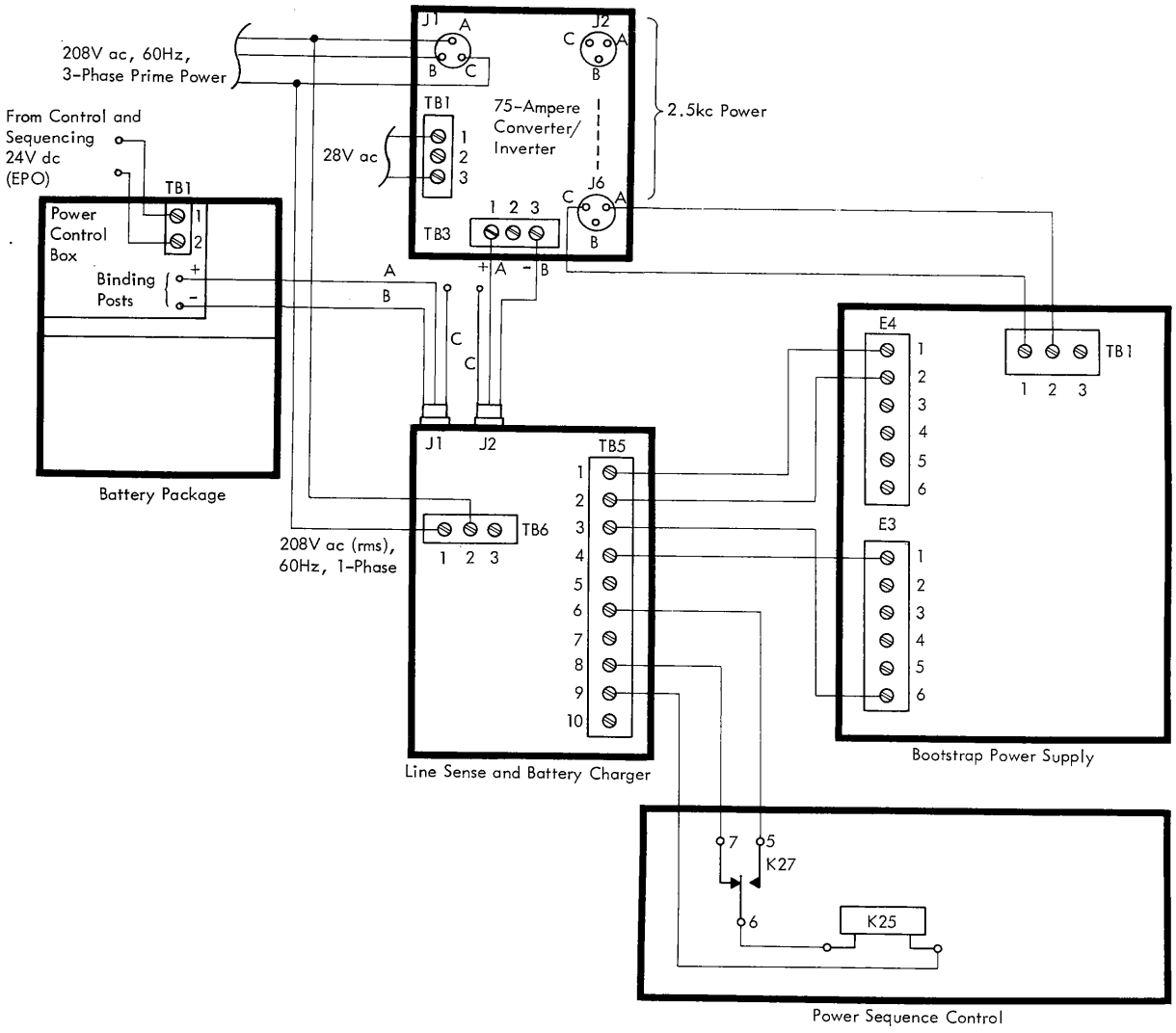


Figure 1-10. Battery Backup Interconnections

be applied to the C/I. This contactor, which is connected across the element MPO contactor, is picked only when the system EPO switch and the element MPO switch are closed (Figure 1-9). Thus, when an emergency power off is executed (EPO or MPO switch activated), K1 is dropped, interrupting the battery package output. This interrupt is achieved by opening the contacts of K1 which are connected in series with the battery package output.

Battery Charger

- 150-ma average recharge current.
- A rectified charger waveform is determined by time-ratio control of an SCR.
- A neon lamp at the battery charger indicates proper operation.

The battery charger circuit (Figure 1-11) supplies an average recharge current of 150 ma to the battery package (J1-A and J1-B). The input to the charger circuit is 208V ac (TB6-1 and TB6-2). The secondary of transformer T1 produces rectified 550V peak full-wave segments.

The portion of the rectified waveform fed to the battery package is determined by time-ratio control of the firing of SCR2. SCR2 is gated on when the base of transistor T2 is more positive than the base of transistor T3. This condition causes T2 to conduct, turning on T4 which acts as a constant current source for capacitor C37. The voltage across C37(e) rises linearly with time until it equals 0.6 of the difference between b_2 and b_1 of unijunction transistor T5. At that time, a current surge is felt across the primary of T_X21. This surge gates SCR2, transferring the remaining portion of the cycle of the rectified waveform (from the high-voltage winding of T1) to the battery package.

The value of current generated by T4 determines the rate at which C37 charges to the breakdown point of T5. This current value is determined by the voltage established on the base of T4. The voltage at the base of T4 is a function of the difference between the reference voltage on the base of T2 and the sensed voltage on the base of T3. The T3 voltage is established by the battery charge current flowing through resistor R2 after it is averaged to a smooth dc value by the filter formed by L1 and C3. Thus, by comparing the average voltage, the firing time of SCR2 is controlled and regulated to the 150-ma average value.

CAUTION
Potentiometer P1 in the base circuit of transistor T2 is factory-adjusted and should not be readjusted at the installation.

The battery charger circuit is operating properly when only the left electrode of neon lamp DS1 is glowing (as viewed through the Plexiglas* fuse window). Improper battery operation is indicated if:
1. Only the right electrode glows.
2. Both electrodes glow.
3. Neither electrode glows.
4. There is an extreme brightness of the indicator.

Bootstrap Power Supply

- Receives 2500-Hz input power from the C/I.
- Supplies output power for:
  1. Marginal voltage sensing.
  2. Power sequencing and control.
  3. C/I bias.
  4. Line sense and switching circuit control and service voltages.

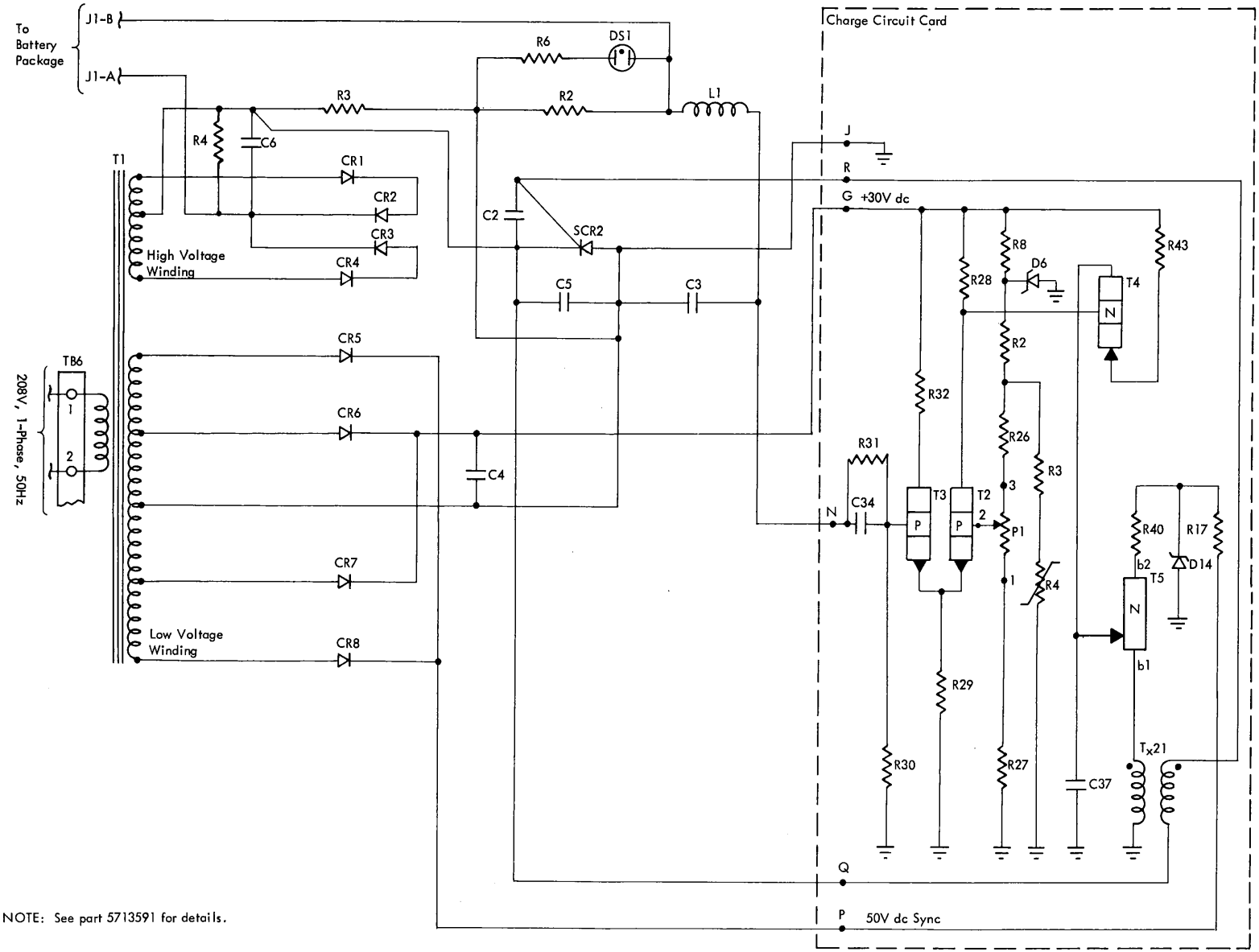
The bootstrap power supply includes transformers and rectifying circuits which provide the necessary sense and control voltages needed for:
1. Marginal (undervoltage) sensing circuitry.
2. +24V dc for prime/battery power sequencing and control.
3. 28V ac for C/I bias.
4. Line sense and switching circuit control and service voltages.

The bootstrap supply (Figure 1-12) receives its input as 2500-Hz, 137V, rms power from the C/I. The C/I receives its input from either the 208V, 60-Hz prime power source or from the battery package. The output from the bootstrap supply, therefore, is not affected in cases of prime power failure, and operation continues because of the battery input to the C/I circuitry.

After the initial phase of power-on sequencing, contactor points switch the prime +24V dc (rectified 60-Hz) out of the power control circuitry and replace it with bootstrap +24V dc (rectified 2500 Hz). The bootstrap power supply, therefore, provides the +24V dc to the power control and sequencing circuitry at all times, except for the short initial period during power-on sequencing. Contactor points also switch the 28V ac C/I bias voltage from the prime power source to the bootstrap supply.

The bootstrap power supply also supplies a +24V dc control voltage to hold the line sense and switching circuit relays (Figure 1-13). A separate +24V dc is also sent to the line sense and switching circuit as a service voltage to the transistor circuitry.

* Trademark of Rohm and Haas Company



NOTE: See part 5713591 for details.

Figure 1-11. Battery Charge Circuit

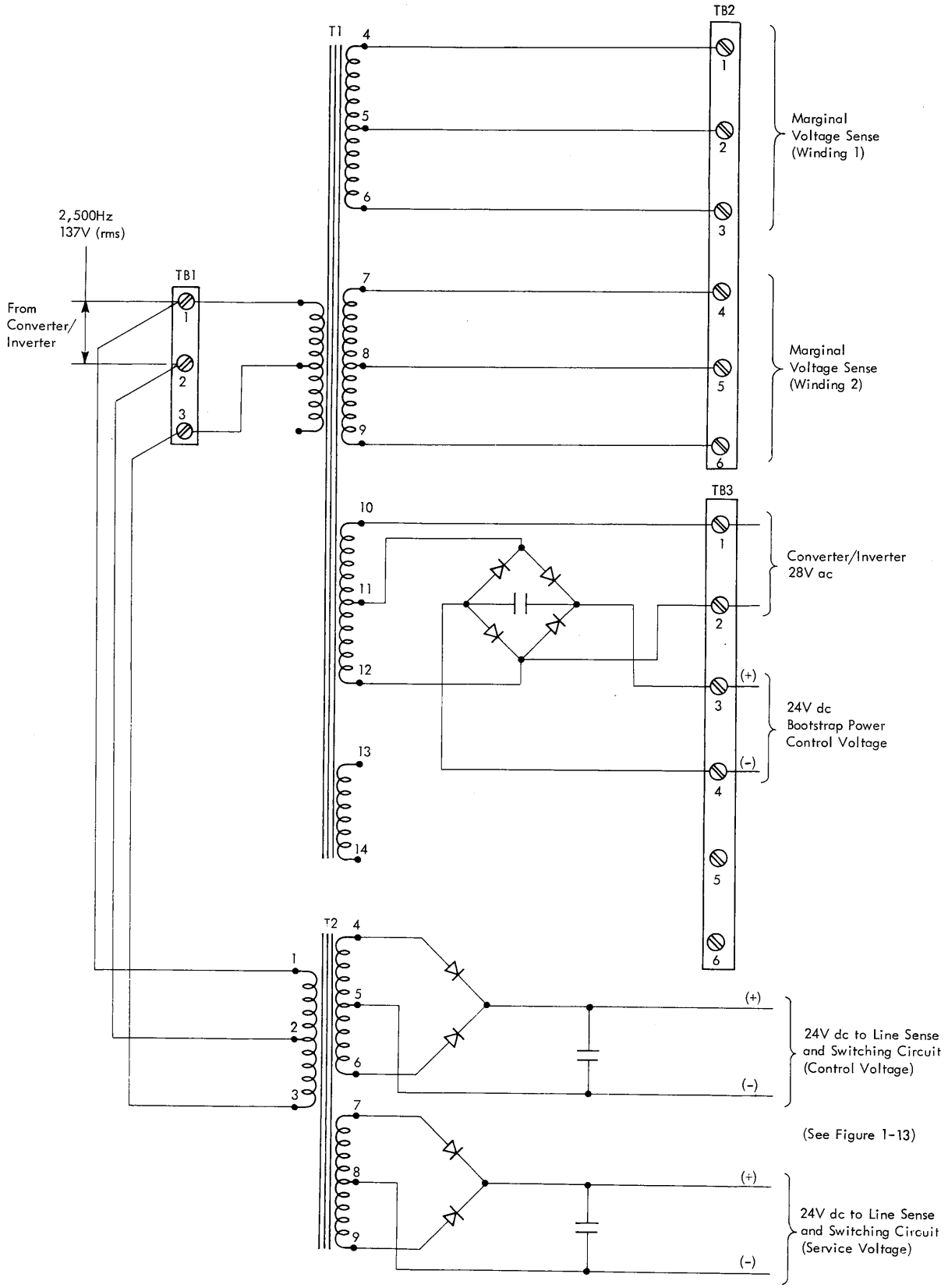


Figure 1-12. Bootstrap Power Supply

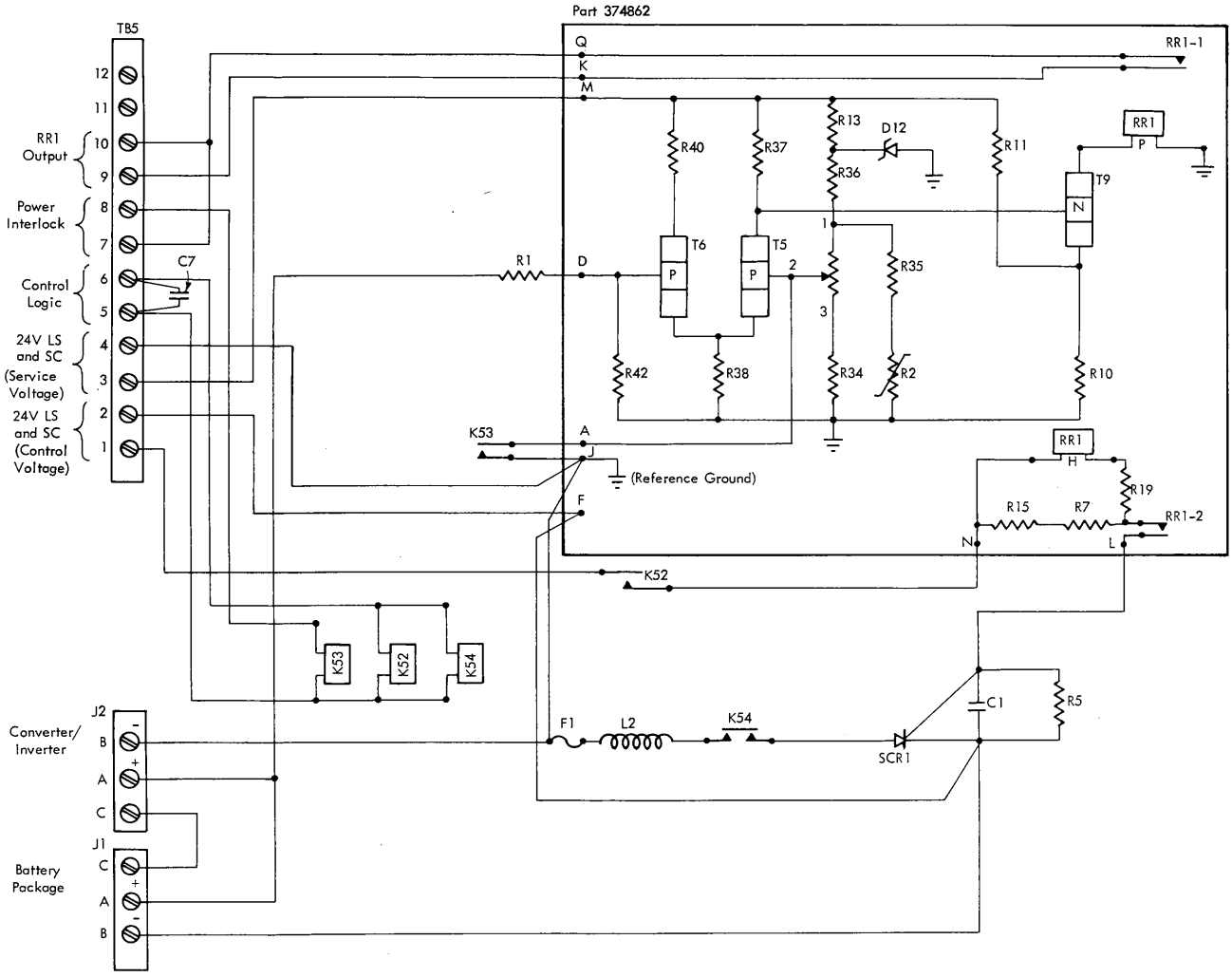


Figure 1-13. Line Sense and Switching Circuit

Marginal check sense outputs are provided from the bootstrap supply for use as reference voltages in the undervoltage protection circuits.

Line Sense and Switching Circuit

- Automatically senses loss of input power and electronically switches the battery supply into the C/I.
- Interlock circuits allow battery power switching to occur only under normal power loss conditions.

The line sense and switching circuit (Figure 1-13) automatically switches the element to battery power when the sense circuit senses that the voltage on the dc bus between the converter and inverter has fallen to approximately 240V dc from its normal 290V dc operating voltage. This effectively senses a loss of (or drop in) prime input power from 208V ac to approximately 181V ac.

The sense circuit includes a differential amplifier (T5 and T6) and a relay circuit (T9 and RR1). When the dc output of the C/I (J2-A) is more negative than the T5 base input, T5 is turned on. The base input to T9 is now negative, causing T9 to conduct and pick reed relay RR1.

Relay K53 in the line sensing package is picked by element power interlock circuitry, and its N/O points disable the line sense circuitry by grounding the input to transistor T5, thereby cutting it off and preventing it from turning on transistor T9 to pick RR1.

CAUTION

The potentiometer in the base circuit of transistor T5 is factory-adjusted and should not be readjusted at the installation.

Relay K52 and contactor K54 in the line sense package arm the SCR in the switching circuit. K52 and K54 are picked together, and are controlled by the element power logic circuitry. K52 arms the gate circuit to the SCR when its picked, and K54 arms the anode circuit when its picked. K52 and K54 are held picked, and K53 is dropped during normal power-on conditions within an element.

When the line sense circuit has sensed a drop in the C/I dc bus and picked RR1, the RR1-2 N/O points gate the SCR in the switching circuit into conduction and establish a hold circuit for this gate together with the K52 N/O points. When the SCR conducts, battery power is fed to the C/I dc bus so that the C/I 2500-Hz output continues uninterrupted to maintain the element's power.

An additional set of RR1 points is used by the element's power sequencing circuitry to pick a relay called "on battery".

This on-battery relay causes an on-battery time delay relay to start timing out. The on-battery relay is also used by the element power sequence circuitry to signal the logic circuits of an on-battery condition. When the on-battery time delay relay times out (5.5 seconds for SE and DE; 6.5 seconds for CE and IOCE) and picks, its N/O points drop K52 and K54 in the line sense package. When K54 drops, its points open the anode circuit of the SCR, cutting off the flow of battery current to the C/I dc bus. When K52 drops, its points open the gate circuit to the SCR. If the Prime 208V ac power is restored within the on-battery limit time period, the element goes back on that prime 208V ac and is ready to go on battery power again in case of another 208V ac prime power loss. If no 208V ac prime input, the element starts a normal power-down sequence.

Some of the conditions which could disable the sense circuits within an element and disarm the SCR so battery power could not be applied to that element are:

1. Whenever power is not completely sequenced up.
2. Whenever the element has power up and is in state zero with the TEST switch on.
3. When power is sequenced off because of a thermal, OV/OC, EPO/MPO, or undervoltage condition.

All CE components and circuits associated with power distribution and control (including protection, checking, and backup circuits) are described in this chapter. A general description of protection and checking circuits (including EPO/MPO) and of battery backup power is given in Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- Power assemblies are located in all three frames of CE.
- Two panels for monitoring and control functions.

Figures 2-1 through 2-9 show the power component locations within the CE. The power components are located in all three frames of the CE (frames 01, 02, and 09), and consist of two power distribution units (PDUs) and a battery backup package. The PDUs provide power distribution and power control for the control panel and logic gates of the CE. The PDUs are located in two frames in the CE, frames 01, and 02. The battery backup package is located in frame 09 and consists of batteries, the line sense and switching circuit, a battery charger, and a bootstrap power supply.

Frame 01 (Figure 2-1) contains four power assemblies which make up PDU 1. Their contents are described below:

1. Left power tub (01A): contains eight dc regulators (power supplies 1–8), their overvoltage/overcurrent (OV/OC) sensing and "axe" assemblies, thermal warning and thermal catastrophic sensing switches, and a fan to cool the tub (Figure 2-3).
2. Relay gate (01B): contains relays, two undervoltage sense assemblies, and the maintenance panel (Figure 2-3). The relays are used for power sequencing and control. One undervoltage assembly is for PS1, the 6V nonmarginal power supply; the other is for all the logic power supplies.

   The maintenance panel contains switches and indicators. Switches are used for: power on/off, 48V OV/OC reset, thermal reset, undervoltage check of all logic power supplies, and for simulation of out of tolerance (OTC) and on-battery supply (OBS) conditions. Indicators on the maintenance panel show: power sequence complete, power check, OBS, and thermal conditions occurring in any logic gate or PDU.
3. Right power tub (01C): contains eight dc regulators (power supplies 9–16), their OV/OC sensing and "axe" assemblies, thermal warning and thermal catastrophic sensing switches, and a fan to cool the tub (Figure 2-3).
4. Prime power box (01D): contains a line filter, the +24V dc prime power supply, a 28V ac supply for the converter/inverter control circuitry, a ±20V dc supply to power the undervoltage sense circuits, a 12.6V ac supply to provide timing pulses to the interval timer, a stepdown transformer which supplies 115V ac to the convenience outlets and the keyboard printer, circuit breakers, and fuses (Figure 2-4).

Frame 02 contains two power assemblies which make up PDU 2. These assemblies contain the following:

1. Power tub (02G): contains five dc regulators (power supplies 02G-1 through 02G-5), their OV/OC sensing and axe assemblies, thermal warning and thermal catastrophic sensing switches, and a fan to cool the tub (Figure 2-6).
2. A 75-amp converter/inverter (C/I) (Figure 2-5): consists of a converter section which converts the 208V ac input to about +290V dc, and the inverter section which takes the +290V dc from the converter output and inverts it to 137V ac at 2500 Hz. The C/I contains a fan for cooling.

Frame 09 contains one or two battery packages, depending on whether one or two CEs are attached to this frame (Figure 2-7). The bottom battery package is always attached to the lower numbered CE (i.e., CE 1, if CE 1 and CE 2 are attached to this frame). These battery packages consist of:

1. A battery charger and bootstrap assembly (09A if attached to the lower numbered CE or 09C if attached to the higher numbered CE), which contains a line sense and switching unit, a battery charger, and a bootstrap power supply (Figure 2-8).
2. A battery box (09B if attached to the lower numbered CE or 09D if attached to the higher numbered CE), which contains two battery trays and a power disconnect section, fuses, battery ON/OFF switches, and contactor K1 (Figure 2-9).

The CE control panel contains the following switches and indicators for power monitoring and control functions:

1. An element master power off (MPO) switch for removing power from the CE immediately.

2. A POWER ON/OFF switch used for normal power on/off.
3. Indicators for visual determination of thermal, mainline power on, on battery, power check, and sequence complete.
4. A meter for monitoring the marginal voltage supplies.
5. A rotary switch that selects one of the marginal supplies to the meter.
6. Marginal voltage potentiometers for adjusting the marginal supplies.
7. An indicator, labeled ACTIVE, to visually determine when one of the marginal potentiometers is turned away from its nominal position.
8. An indicator, labeled LOCATE, which works in conjunction with the meter select switch, and which lights if the switch is turned to the position of the supply that is being margined.
9. A TEST switch which is effective when the CE is in state zero.
10. Four STATE indicators which indicate the current operational state of the CE.

Power Interlock Circuitry

- Each CE is power interlocked with System Console (9020D) or Configuration Console (9020E).

- All main power is removed from CE during EPO/MPO conditions.

Power interlocking is such that all main CE power can be removed during EPO/MPO conditions. Pulling the EPO switch on the System Console (9020D) or the Configuration Console (9020E) removes power from all elements on that system; pulling the CE MPO switch removes power from only that CE.

Figure 2-10 shows the CE power interlock circuitry. During normal or EPO/MPO power-off conditions, a prime service +24V dc is still available to the mainline power-on indicator, and to the console EPO circuitry. With the EPO switch closed at the console, the CE (or any element) can pick and hold the EPO contactor in the console. In the CE, the circuit is from the prime +24V dc source, through diode CR13 and isolation diode CR15, to the console, through the EPO switch and EPO relay coil, and to the common 24V dc return.

The N/O EPO points in the console provide the pick circuit for the MPO contactor in the CE. The MPO circuit is through diode CR30, through the MPO switch and the PK1 contactor, to the console, through the EPO relay N/O contacts, and to the 24V dc return.

When PK1 closes in the CE, +24V dc is applied to the power sequence and control circuitry. Operation of the power sequence and control circuitry, which depends upon the setting of the POWER ON/OFF switches, is described later in this chapter.

The main points of PK1 gate 3-phase, 208V ac power into the prime power area of the CE. Operation within the prime power area also depends on the setting of the POWER ON/OFF switches and is described later.

An additional contactor (K1) is connected in parallel with PK1 (Figure 2-10). This contactor is in the battery package and prevents high dc voltage from leaving that area during EPO/MPO conditions.

AC Distribution

- 208V, 3-phase, 60 Hz input power

- Under normal power-off conditions, ac power is available to:
  1. The 115V ac convenience outlets.
  2. The 28V ac converter/inverter control circuitry.
  3. The +24V dc prime power supply.
  4. The 12.6V ac power supply for the interval timer.
  5. The ±20V dc power supply for the undervoltage sense circuits.

- Under EPO/MPO conditions, only the +24V dc prime power exists in the CE.

AC input consists of 3-phase, 208V, 60 Hz power that is routed directly from the facility power outlet to a filter network (Figure 2-11) in the CE. The capacitors in this network eliminate any unwanted electrical noise that could have an adverse effect on the CE circuitry. Each ac feed capacitor in the filter network has a 1-megohm resistor that is connected to ground. These resistors bleed off any charge that remains on the capacitors when the ac service is disconnected.

Turning on mainline circuit breaker CB1 applies 208V ac, single-phase power via fuses F1 and F2 to the +24V dc prime power supply. This supply provides +24V dc power through diodes CR30 and CR13 (Figure 2-10) to the system emergency power-off (EPO) circuit in the system or configuration console. If the EPO switch in the console is closed, the EPO relay in the console picks, providing a return for the element's master power off (MPO) contactor PK1. If the element's MPO switch is closed, +24V dc is applied to the other leg of MPO relay PK1, causing it to pick.

From the contacts of PK1, 208V ac, single-phase power is routed via CB12 to step-down transformer T2, which provides 115V ac power to the convenience outlets in the CE via CB11. Also, 208V ac, single-phase power is routed from CB12 to the system or configuration console via F5 and F6.

From the contacts of PK1, single-phase, 208V ac power is also applied via fuse F3 to CB7 and transformer T4. The secondary of T4 initially supplies 28V ac via relay K22 N/C contacts to the converter/inverter (C/I).

Single-phase, 208V ac power is also applied via F3 to CB2. CB2 controls power for stepdown transformer T3, which supplies 12.6V ac to the interval timer. CB2 also controls power for the ±20V supply which powers the undervoltage sense circuits.

With the contacts of PK1 closed, +24V dc power is now applied to the +24V dc bus through the No. 1 set of contacts in PK1.

Under normal power-off conditions, power is available to the following CE circuitry:

1. 115V ac to the convenience outlets.
2. 28V ac to the C/I control circuits.
3. 12.6V ac to the interval timer.
4. ±20V dc for the voltage sense circuits.
5. +24V dc to the +24V dc bus.
6. +24V dc to the EPO/MPO circuitry.

Note: Under EPO/MPO conditions, power is still available at the 24V dc prime power transformer and +24V dc is still active in the power interlock cable to the system or configuration console. The +24V is needed to return power to the system elements when the EPO/MPO condition is removed. All power can be removed from the CE only by opening CB1 or the facility power outlet breaker for the CE.

Before any further distribution of ac can occur, relay PK2 must be picked (Figure 2-12), described under "Power-On Sequence" later in this chapter. From the contacts of PK2 (Figure 2-11), 208V ac is applied via CB9 to the C/I, to CB8, and to the line sense and battery charger. Within the C/I, the 208V ac input is routed through CB2, to the converter section and to the C/I fan. CB8 controls the 208V ac, single-phase power to all the other fans and blowers within the CE. Also, when PK2 picks, 115V ac power is routed through fuse F4 to the keyboard printer.

When the C/I is on, its 137V ac, 2500 Hz square wave output is routed to the standard dc voltage regulators and to the bootstrap power supply. This bootstrap power supply, in turn provides the following voltages:

1. 28V ac for the C/I control circuitry.
2. ±20V dc to the undervoltage sense assemblies.
3. +24V dc to the line sense and switching circuit.
4. +24V dc via N/O contacts of K8 or K22 to the coil of bootstrap transfer relay K22.
5. +24V dc for the +24V dc bus.

When K22 is picked, the bootstrap power supply provides the 28V ac input to the C/I and +24V dc to the +24V dc bus (Figure 2-12), through the N/O contacts in PK1.

DC Distribution

- Twenty-one dc voltage regulator supplies.
- 2500 Hz primary input to all regulators.
- All supplies except 48V and 6VNM are sensed by the same undervoltage sense circuit.

All dc voltages, except the +24V dc prime and bootstrap power, the +25V dc regulator bias, and the ±20V dc power for the undervoltage sense assemblies are obtained from regulators.

The CE contains 21 dc regulators (Figure 2-13). More than one of each type of regulator is used except the 48V, −18V, and +6NM regulators. Input power to the 21 dc regulators is from the C/I as a 2500-Hz, 137V (rms) square wave.

Application of the input is such that the regulator voltages come up in three groups: the logic voltages (+3, −3, +6, +18), the +6VNM, and the 48V supply. Inputs to the last two supplies (Figure 2-13) are under control of contactors PK6 (+48V supply) and PK19 (+6VNM supply). This operation is described in detail under "Power-On Sequence" soon to follow.

Each regulator except the +6VNM and the +48V is monitored by a common logic undervoltage detect circuit which controls the proper power on and off sequencing in the CE (Figure 2-12). Outputs of the dc regulators are distributed to the CE logic gates. Table 2-1 lists the dc regulators with their voltage and current ratings and the gates to which power is applied.

Power-On Sequence

- DC voltages sequence up in three groups:
  1. Logic voltages
  2. +6VNM
  3. +48V supply

Refer to Figures 2-12 and 2-14. Figure 2-12 shows power sequence and control circuitry. Use Figure 2-14 (power-on flowchart) to follow the operation of this circuitry during a power-on sequence.

Before the power-on sequence in the CE can begin, CB1 must be closed and the system or configuration console EPO contactor and the element MPO contactor PK1 must

Table 2-1. DC Regulator Data

Reg No.	Location	Rating	Load (Gate Area)
1	01A Left Tub	+6VNMDC @25A	02C, D, + E Upper
2	01A Left Tub	+3VDC @40A	02B Lower (except D4, E4)
3	01A Left Tub	+3VDC @40A	02E Lower
4	01A Left Tub	- 3VDC @40A	02C + D Upper + E3 02C + D Lower
5	01A Left Tub	+3VDC @40A	02E Upper
6	01A Left Tub	+3VDC @40A	02C + D Upper 02C + D Lower
7	01A Left Tub	+6VMDC @40A	02E Upper 02E Lower
8	01A Left Tub	+6VMDC @40A	02C + D Lower
9	01C Right Tub	48VDC @2A	Printer-Keyboard
10	01C Right Tub	- 3VDC @40A	02A, + E Upper 02A + E Lower
11	01C Right Tub	- 18VDC(ROS) @11A	02C Upper
12	01C Right Tub	+3VDC @40A	Indicators 02A Lower (except B3, B4)
13	01C Right Tub	+3VDC @40A	02B Upper (except D1, E1)
14	01C Right Tub	+3VDC @40A	02A Upper Indicators
15	01C Right Tub	+6VMDC @40A	02B Upper 02B Lower
16	01C Right Tub	+6VMDC @40A	02A Upper 02A Lower
1	02G	+3VDC @40A	02B Upper (D1 + E1) 02B Lower (D4 + E4) 02A Lower (B3 + B4)
2	02G	- 3VDC @40A	02K + L 02B Upper + Lower
3	02G	+3VDC @40A	02L
4	02G	+3VDC @40A	02K
5	02G	+6VMDC @40A	02K + L

be energized. With these requirements satisfied, the following conditions exist prior to the power-on sequence:

1. The MAINLINE ON indicator is on.
2. The POWER CHECK indicators are on through the N/C contacts of K8 to indicate that a normal power-off situation prevails.
3. All the thermal sensing elements are in the N/C position (not activated) and thermal relays K2–K4, K9, K14–K17, and K24 are picked through K7 N/C contacts. Each relay also is held through its own N/O contact.
4. CB1, CB2, CB7, and CB9 are closed, relay K5 (OTC) remains de-energized, K1 in the C/I remains de-energized, and CB2 in the C/I is closed.
5. Relay K28 (25V dc regulator bias present) is picked.

With these initial requirements satisfied, the power-on sequence is begun by turning on both POWER ON/OFF switches, which completes the circuit that picks relay K13 (power on/off). Included in this pick circuit are the K1-5 N/C contacts within the C/I. When contactor K1 in the C/I is not energized, the three K1 N/O points ensure that a starting series resistance is in series with the 208V ac input to limit the initial power surge and prevent possible damage to C/I diodes CR1 to CR6. If, for some reason, the K1 contactor is not dropped at the time power is turned on, the pick circuit to K13 cannot be completed, and power cannot be sequenced on until this trouble is corrected.

As power comes up in the C/I, K1 picks and the K1-5 points open. At this time, however, a hold circuit for K13 has been established through the K13 N/O points.

At the same time K13 is picking, the pick circuit for time delay relay K12 (sequence start delay) is established through the N/O points of K28 (25V dc bias present), which was picked previously, and K12 starts timing out. K12 is adjustable for a 5–30 second delay, and is set to allow staggering of elements powering on in the 9020 system.

The N/O points of K13 establish a pick circuit for relay K7 (auto thermal set and thermal reset), and K7 holds through its N/O point until a manual thermal reset is begun or an EPO or MPO condition occurs. The picking of K7 removes the auto thermal set from the thermal relays. These relays should all be held through their respective N/O points at this time if no thermal condition is present in the CE.

When sequence start delay relay K12 times out, its N/O points close and establish pick circuits for time delay relay K30 (sequence interlock time delay) and contactor PK2 (CE power on). K30 is a 5-second time delay relay. If power is not up when K30 picks, a sequence interlock power-off sequence is initiated to prevent a hang condition. Under normal conditions, therefore, the K30 points close

after power is sequenced up. PK2, the ac-on heavy duty contactor that K12 picked, then applies 208V ac, 60-Hz power to the following components:

1. The C/I and its fan.
2. All other fans and blowers in the CE (via CB8).
3. The line sense and battery charger.

The C/I then applies 137V ac (rms) at 2500 Hz to the following components:

1. All dc regulator power supplies except the +6VNM and the +48V supply.
2. The bootstrap power supply, which then provides parallel power to:
   a. The bias supply for the UV sense assemblies which were previously powered only by the ±20V dc supply in the prime power box.
   b. The +24V dc bus which was previously powered only by the +24V dc prime power supply.

The bootstrap supply starts supplying 24V dc power to the line sense and switching circuit. It also provides a 28V ac at 2500 Hz which will be used later in the power-on sequence to supply the C/I control circuitry. This 28V ac is presently being supplied by 28V ac prime power.

At this time, all power supplies which have been energized should be up and within tolerance. If so, relays K10 and K11 in the logic UV sense circuit will be picked. The N/O points of K10 and K11 then energize contactors PK19 (6VNM supply disconnect) and PK6 (48V supply disconnect). K30 (through K10 and K11) sends + power on reset and – power on reset to the CE logic circuits. These lines force a state zero condition in the CE.

The picking of PK19 and PK6 allows 2500 Hz from the C/I to power the +6VNM supply and the 48V supply respectively. When the +6VNM supply is up and within tolerance, relay K20 (6VNM voltage sense) picks. If the TEST switch is on along with state zero when the 6VNM supply comes up, K21 (power bit interlock) will pick at this time.

When K20 picks, its points send +CE power on and + 1052 adapter power on to the CE logic circuits. Also, K20 will hold K31 up after K30 (sequence interlock time delay) times out. It also picks relay K8 (sequence complete).

When K8 picks, it holds itself through its N/O points. The picking of K8 drops out relay K27, picks relay K22 (bootstrap transfer), holds contactor PK2 with prime +24V dc power, drops the 'power check' line to the system or configuration console, puts out the POWER CHECK lamps. and lights the POWER SEQUENCE COMPLETE lamps.

When K22 picks, it holds itself with 24V dc bootstrap power through its N/O points, and transfers the 28V ac C/I bias which came from the prime 28V ac power supply to the bootstrap power supply.

The dropping of K27 causes relay K53 (disarm line sense) in the line sense and switching circuit to drop out and causes relays K52 (arm gate circuit of SCR) and K54 (arm anode circuit of SCR) to pick.

Next, K30, the sequence interlock time delay relay, times out. If there is no catastrophic thermal condition (K24 is still picked), dc regulator bias is present (K28 picked), and the 6VNM supply output is within tolerance (K31 picked). The CE stays powered up.

After power is up, the CE is in operational state zero. If the TEST switch is off, or the CE is taken out of state zero, relay K21 (power bit interlock) picks through logic circuitry, and holds through its N/O points. The K21 N/O points, in parallel with the POWER ON/OFF switches, provide a parallel hold circuit for K13 (power on/off) which effectively disables the POWER ON/OFF switches. The CE must be in state zero with the TEST switch on for the POWER ON/OFF switches to be effective.

Normal Power-Off Sequence

- Battery backup is prevented from switching into CE during power-off.
- CE must be in state zero with TEST switch on to perform a normal power-off.

Refer to Figures 2-12 and 2-15. Figure 2-12 shows power sequence and control circuitry. Use Figure 2-15 (Power-Off Flowchart) to follow the operation of this circuitry during a normal power-off sequence.

To begin a normal power-off sequence, the CE must be in state zero with the TEST switch on. Together, these two conditions drop relay K21 (power bit interlock) and allow the POWER ON/OFF switches to become operative. The dropping of relay K21 picks relay K27 (line sense and switching circuit conditioner). When K27 picks, it drops relays K52 (arm gate circuit of SCR) and K54 (arm anode circuit of SCR), and picks relay K53 (disarm line sense).

Next, either POWER ON/OFF switch is turned to OFF, which drops relays K13 (power on/off), K12 (sequence start delay), and K30 (sequence interlock time delay).

De-energizing K13 resets the following lines going to the CE logic circuits:

1. + Power-on reset
2. – Power-on reset
3. + CE power on
4. + 1052 adapter power on

K13 also drops PK19 (6VNM supply disconnect) which drops the 6VNM supply. When the 6VNM supply drops, K20 (6VNM sense relay) drops, causing relay K8 (sequence complete) to drop out.

When K8 drops, it drops out contactor PK2 (CE power on), turns off the POWER SEQUENCE COMPLETE indicators, turns on the POWER CHECK indicators, and sends 'power check' to the system or configuration console.

When PK2 drops, it cuts off 208V ac power to the C/I, to all fans and blowers, and to the line sense and battery charger circuits. The C/I 137V ac, 2500 Hz output falls, and the dc regulators which it powers are de-energized. The logic UV sense assembly detects an undervoltage condition, and K10 and K11 (voltage sense relays) drop out, causing contactor PK6 (48V supply disconnect) to drop.

When the C/I power falls off, the bootstrap supply also drops out, and K22 (bootstrap transfer relay) drops out.

All dc voltages have now been removed from the CE except the +24V dc prime power to the +24V dc bus and power interlock circuitry and the ±20V supply voltages for the undervoltage sense circuits. The ac voltages remaining are the prime 28V ac bias supply for the C/I, 12.6V ac to the interval timer, and 115V ac to the convenience outlets.

Battery Backup Power Control

- Uninterrupted battery backup power for 6.5 seconds.
- Loss of 208V ac input power is sensed as a decay in voltage within the C/I.
- Battery backup is not applied under EPO/MPO conditions.
- The CE cannot go on battery power in state zero with the TEST switch on.

The CE has a battery backup power source that permits uninterrupted power for 6.5 seconds following the loss of the 208V ac input power to the CE.

To go on battery power, the CE must have relay K21 (power bit interlock) picked. As long as the CE is not in state zero with the TEST switch on, K21 is picked.

Loss of primary 208V ac power is sensed by the line sense and switching circuit as a decay of the voltage on the converter dc bus to the inverter. When this voltage drops below a preset limit (240V dc), reed relay 1 (RR1) in the line sense unit picks and fires an already conditioned silicon control rectifier (SCR) in the line sense and switching circuit. Battery power is then fed onto the dc bus between the C/I sections (Figure 2-16). This high-speed switching occurs without interruption to the 137V ac, 2500-Hz C/I output.

Note: The battery package (Figure 2-17) is not applied during an EPO or MPO condition because the coil of K1 the battery package is in parallel with the coil of the MPO contactor (PK1), and the N/O contacts of K1 are in the output circuit of the battery supply.

Figure 2-18 is a sequence chart that shows the CE battery backup power sequencing when either prime power is restored within the 6.5-second on-battery time limit or power sequences down in the CE because power was not restored within the 6.5-second on-battery time limit period.

Battery Backup with Prime Power Restored

- Battery power is removed automatically and replaced with main power after 6.5 seconds.

When the SCR in the line sense and switching unit switches battery power into the CE, RR1 has been picked in the line sense and switching circuit and provides a pick circuit for K25 (on-battery). The N/O points of K25 light the on-battery indicators in the CE and on the console. K25 also causes the + 'OBS check' signal to be sent to the CE logic circuits. It also starts time delay relay K23 (on-battery limit timer) to start a 6.5 second timeout (Figure 2-12).

Loss of 208V ac prime input power causes: contactor PK2 (AC on) to drop, the MAINLINE ON indicator to go off, 12.6V ac to the interval timer in the CE to drop, 115V ac to the convenience outlets and the printer keyboard to drop, 208V ac to the console printer to drop, all fans and blowers to stop, the prime +24V dc and prime ±20V dc power supplies to drop, and the prime 28V ac bias supply to drop (Figure 2-11).

When prime 208V ac input power is restored, all the supplies that dropped when it was lost come up again, and the fans and blowers come back on. The +24V dc from the prime power supply then picks contactor PK2 (AC on), picks relay K26 (prime power restored) through the K25 N/O points and turns on the MAINLINE ON indicators. When the PK2 points close, 208V ac input is restored to the C/I and its fan.

The power control circuitry recognizes the restoration of prime power by K26 being picked, and, even though prime power has been restored before the timeout period (6.5 seconds) of K23 (on-battery limit timer), battery power is used for the duration of the 6.5 seconds. Battery power is maintained by relay K54 in the line sense and switching circuit conditioner) through the combination of K26 N/O and K23 N/O both being closed. When K27 picks, it drops out relays RR1, K52, and K54; picks K53 (line sense disarm); and provides a hold circuit for K26. When relay K54 drops, it cuts off the battery power to the dc bus between the converter and inverter actions and shuts off

the SCR. When RR1 drops, it drops out K25 (on-battery supply). When K25 drops, its N/O points drop K23 (on-battery limit timer), turn off the OBS indicators, and drop the '+ OBS check' line to the CE logic circuits. K23 then drops relay K27. When K27 drops, it drops K53 (disarm line sense) and K26 (prime power restored), and picks relays K52 and K54 (arm gate and anode circuits of SCR). The system is again operating from prime power, the line sense and switching circuit has been conditioned again, and battery backup is ready for another emergency.

Battery Backup without Prime Power Restored

- 6.5 seconds of battery backup.
- Power is automatically sequenced off after 6.5 seconds.
- Power is automatically sequenced on when prime 208V ac power returns.

The sequence proceeds as described in the previous section, with battery power going to the CI, relay K25 (on battery) being picked, 6.5-sec time delay, and with relay K23 (on battery limit timer) timing out.

If prime power is not restored within 6.5 seconds, time delay relay K23 times out, and its N/C contact in the pick circuit of contactor PK19 (6VNM supply disconnect) opens and drops the 6VNM supply. When this supply drops, it drops relay K20 (6VNM voltage sense) and relay K21 (power bit interlock). When K20 drops, it drops out relays K8 (sequence complete) and K31 (6VNM undervoltage conditioner). K20 also resets '+ CE power on' and '+ 1052 power on' to the CE logic circuitry. When K21 drops, it picks relay K27 (line sense and switching circuit conditioner). When relay K31 drops, it picks relay K29 (initiate power down sequence). When K8 drops, it turns on the POWER CHECK lights in the CE and console, and turns off the POWER SEQUENCE COMPLETE indicators in the CE.

When relay K27 picks, it drops relays K52 and K54 and picks relay K53. The dropping of K54 opens the battery supply to the C/I, permitting the C/I output to decay. As K29 picks, it resets '+ power on reset' and '– power on reset' to the CE logic circuits and holds itself through its own points.

As the C/I output decays, it cuts off power to all regulators and the bootstrap supply. As the bootstrap power decays, its +24V dc to the +24V dc bus drops off and all relays in the CE drop including PK1, the MPO relay. Under loss of 208V ac power conditions, no prime power is available, no relays in the CE are picked, no indicators are on, and the only power remaining in the machine is within the battery package.

Emergency Power-Off Sequence

- EPO/MPO conditions immediately remove all power, except 24V dc prime.
- Normal power-off sequencing is bypassed.
- Battery backup is prevented under EPO/MPO conditions.

If either the system EPO or the CE MPO pull switch is pulled, all power is turned off in the CE except the prime +24V dc supply. The EPO/MPO switches are mechanical latch-type switches that must be reset manually.

Pulling either the EPO or MPO switches causes PK1 (MPO) and K1 (in the battery package) to drop in the CE (Figures 2-11 and 2-12). The PK1 points immediately remove all power to the power components and to the +24V dc bus, preventing normal power-off sequencing.

With power removed from the C/I, all regulators drop simultaneously and remove all power from the CE logic circuitry.

The dropping of K1 in the battery packages prevents battery power from leaving the battery package area, preventing battery backup.

Under EPO/MPO conditions, prime +24V dc is still within the power interlock cable that connects the CE and the console. This voltage is necessary so that power can automatically sequence up when the EPO/MPO condition is removed.

Special Power-Off Sequences

Five special power-off sequences are described in the following text: two power-off sequences (logic UV and 6VNM UV) result from undervoltage; one (OV/OC) results from an overvoltage/overcurrent condition; one (thermal check) results from an overtemperature condition; and one (sequence interlock) results from a hang condition in the power-on sequence.

Logic Undervoltage Power-Off Sequence

- All regulators except +6VNM and +48V are sensed by logic undervoltage sense circuit.
- Undervoltage condition automatically sequences power off.
- Power does not sequence up again until POWER ON/OFF switch is turned off and then on.

Each CE regulator except the +6VNM and +48V supply is sensed by the logic undervoltage sense circuit (Figure 2-19). All the positive regulators (+3, +6) are sensed by one circuit which picks relay K10 (voltage sense plus volts), and all the negative regulators are sensed by one circuit that picks K11 (voltage sense minus volts). If any positive or negative supply drops below its minimum allowable output voltage, it drops out relay K10 or K11 respectively, unless the UNDER VOLTAGE CHECK switch for that supply is turned off.

The logic Undervoltage check circuit, physically located on the 01B relay gate, functions as follows: Lines from all positive regulators except PS1 and PS9 are fed through isolation switches, labeled UNDER VOLTAGE CHECK, to an AND circuit. The output level of the AND is determined by the lowest input level; that is, the one nearest zero or ground. Thus, if any supply is off and not isolated by its UV check switch, the output level of the AND is near zero. However, if all the supplies are on, the output level of the AND is about +3V. The output of the AND is transferred directly to the base of transistor Q1, which shares an emitter load resistor with Q2. The base of Q2 is held at +2.4V by Zener* diode CR59 and resistor R8. Q2 now carries the full emitter load current and holds the common emitter circuit to +2.4V. With its emitter held positive with respect to its base, Q1 is biased off. As the output level of the AND raises the base of Q1 to +2.4V, Q1 begins to conduct and starts to share with Q2 the current drawn by the emitter load resistor. As Q1 conducts, the common emitter circuit rises above +2.4V. With its emitter raised to a level positive with respect to its base, Q2 is biased off. Q1 now carries the full emitter load current, which is sufficient to pick K10.

A similar circuit, of opposite polarity, checks the negative regulators and picks K11.

The UNDER VOLTAGE CHECK switches permit CE dc power to be brought up for servicing purposes with a low output-voltage level from a regularor by isolating the output of that regulator from the logic undervoltage sense circuit. These switches are kept closed during normal operation.

When either K10 or K11 drops, it first drops contactors PK19 (6VNM supply disconnect) and PK6 (48V supply disconnect) and resets '+ power-on reset' and '– power on reset', which go to the CE logic circuits (Figure 2-12).

Next, due to the output of the 6VNM supply falling, relays K20 (6VNM sense) and K21 (power bit interlock) drop out. When K20 drops out, it drops relays K31 (6VNM undervoltage conditioner) and K8 (sequence complete) and resets '+ CE power on' and '+ 1052 adapter power on', which go to the CE logic circuits. When K21 drops, it picks relay K27 (line sense and switching circuit conditioner).

When K31 drops, it picks relay K29 (initiate power down sequence). When K8 drops, it turns off the SEQUENCE COMPLETE indicators, turns on the POWER CHECK indicators, sends 'power check' to the console, and drops PK2 (CE power on).

When K29 picks, it drops relay K30. When K27 picks, it drops relays K52 (arm gate circuit of SCR) and K54 (arm anode circuit of SCR) and picks relay K53 (disarm line sense). These relays disarm the line sense switching circuit at this time, so battery power cannot be switched into the C/I.

When K29 picks, it holds through its N/O points and drops out K30 (sequence interlock time delay). The drop of K30 then picks relay K31 (6VNM undervoltage conditioner). Because PK2 has dropped and the battery backup has been disarmed, power to the C/I is cut off and its output begins decaying.

All dc regulators then drop, ending the CE power-down sequence. With K29 holding itself through the POWER ON/OFF switches and its own points, the only way power can be sequenced up again is to turn a POWER ON/OFF switch off (to drop K29) and then back on again to start a normal power-on sequence.

6VNM Undervoltage Power-Off Sequence

- 6VNM supply has its own undervoltage sense circuit.
- Undervoltage condition automatically sequences power off.
- Power does not sequence up again until POWER ON/OFF switch is turned off and then on.

When the 6VNM supply output drops below a minimum allowable output level (+5.25V), it drops out relay K20 in the 6VNM undervoltage sense circuit, which starts a power-down sequence unless the UNDER VOLTAGE CHECK switch for PS1 is off. Figure 2-20 shows the 6VNM regulator undervoltage protection circuit. This circuit located on the 01B relay gate, functions as follows:

Bias voltage for transistor Q1 is supplied by the bootstrap power supply and is maintained at +10V by Zener diode Z1. Potentiometer R1 is adjusted so that Q1 conducts while the regulator output is +5.25V or above. With Q1 conducting, K20 is energized. If the regulator output drops below +5.25V, Q1 is cut off and K20 is de-energized.

When K20 drops, it drops out relay K31 (6VNM undervoltage conditioner) as shown in Figure 2-12. When K31 drops, it picks relay K29 (initiate power-down sequence). K29 then holds itself through its own points and drops relays K30 (sequence interlock time delay) and PK19 (6VNM supply disconnect). As K30 drops, it picks relay K31.

* Trademark of Hoffman Electronic Corporation.

When PK19 drops, it cuts off the C/I 2500 Hz input to the 6VNM supply, causing the 6VNM supply output to decay. PK19 also drops out K8 (sequence complete). As the 6VNM supply output decays, it drops relay K21 (power bit interlock). When K21 drops, it picks relay K27. From here on, the power-off sequence is the same as that of a logic undervoltage condition previously described, and the POWER-ON/OFF switch must be turned off (to drop K29) and then back on again to start a normal power-on sequence.

If the UNDER VOLTAGE CHECK switch for PS1 is off, it allows CE dc power to be brought up for servicing purposes with a low output-voltage condition from PS1. When this switch is off, its contact points are closed. They provide a hold circuit for K31 through CR28, CR34, PS1 N/O, K11 N/O, K10 N/O, K23 N/C, K13 N/O, and K29 N/C.

Overvoltage/Overcurrent Power-Off Sequence

- Each regulator contains an overvoltage/overcurrent (OV/OC) protect circuit.
- An OV/OC condition automatically sequences power off.
- PS1 "axe" assembly prevents system reset.
- Power does not sequence on until regulator OV/OC condition is reset and POWER ON/OFF switch is turned off and then on.
- Battery backup is prevented under OV/OC conditions.

Each CE regulator has an OV/OC protection circuit. If an OV/OC condition occurs in a given regulator, its respective OV/OC protect circuit shorts the regulator output to ground and starts a power-down sequence in the CE control circuitry.

A typical OV/OC protection circuit for the dc regulators in the CE is shown in Figure 2-21. Basically, this circuit includes an OV/OC assembly on an SMS card, and an "axe" assembly that connects across the output bus of the regulator. An "axe" is a circuit which rapidly shorts (axes) the output of a regulator to prevent damaging the circuits which that regulator powers.

Current is sensed by a current transformer in the regulator control circuit whose output is applied to a differential amplifier in the sense section of the OV/OC SMS card. When the maximum voltage or current limit is exceeded, the differential amplifier is turned on to gate the SCR in the axe assembly into conduction, and to pick the reed relay on the OV/OC SMS card. When the SCR on the axe assembly conducts, it shorts the output of the regulator to ground to prevent damage to the circuits which that regulator powers. When the reed relay picks, one set of RR-1 contacts shorts out the control winding of the magnetic amplifier in the regulator control circuit, one set of contacts energizes the reed relay hold coil and lights the OV/OC indicator with 25V dc regulator bias from the C/I, and one set of contacts is used to start a power-down sequence in the CE control circuitry. The OV/OC indicator is used to visually determine which dc regulator in the CE had the OV/OC condition.

A special "axe" assembly is provided for PS1 as shown in Figure 2-22. Its purpose is to prevent the possibility of a system reset being sent to other CEs in the system if a voltage circuit is inadvertently shorted to ground while the CE is being serviced. An OV/OC condition detected in any one of the three voltage circuits that could cause a system reset causes the SCR to conduct. This provides a short circuit across PS1 output which causes the voltage to drop very rapidly. Since PS1 provides voltage to interface output drivers (including system reset), any tendency for the drivers to conduct will be canceled.

The N/O contacts of any of the OV/OC sense relays (Figure 2-12) pick relay K29 (initiate power down sequence). The K29 N/O points open the circuit to PK19 (6VNM supply disconnect), and from there on, a normal power-off sequence is started. After power has been sequenced off, K13 (power on/off) remains picked because the POWER ON/OFF switch is still set to ON.

To restore power to the CE, the OV/OC condition must be reset manually at the C/I, and the POWER ON/OFF switch must be turned off, then on.

Pressing the RESET pushbutton at the C/I opens the 25V dc bias line to the dc regulators (Figure 2-21), which drops the reed relay and turns off the indicator on the OV/OC SMS card. When the reed relay drops, it allows the control winding of the magnetic amplifier to function and opens the pick circuit for relay K29 in the CE control circuitry. Power can now be sequenced up.

The K2-2 points in parallel with the RESET pushbutton in the C/I (Figure 2-21) prevent opening of the 25V dc bias line to the regulators by accidental pressing of RESET while power is up normally in the CE. K2 in the C/I picks as power comes up in the C/I.

If the OV/OC condition has not been reset when the POWER ON/OFF switch is turned back on, K29 picks through the K12 N/O points and the OV/OC reed relay N/O points. The K29 N/C points prevent PK2 (CE power on) from picking, thereby preventing a power-on sequence.

In all cases of OV/OC, the K27 N/C points decondition the line sense and switching circuit by picking K53 (disarm line sense) and dropping K52 (arm SCR gate) and K54 (arm SCR anode), thereby preventing the battery backup supply from sustaining power for an additional period of time.

Note: When RESET is pressed at the C/I, hold it for a few seconds. A momentary depression is not enough time to reset the OV/OC reed relay and gives a false impression of a second OV/OC condition.

Thermal Check Power-Off Sequence

- A catastrophic thermal condition immediately sequences power off.
- A thermal warning condition does not sequence power off but generates a signal (OTC) to alert program of this condition.
- Power is not sequenced up until thermals are reset and POWER ON/OFF switch is turned off and then on.
- Battery backup is prevented under catastrophic thermal conditions.

Two types of thermal checks (thermal warning and thermal catastrophic) can occur in the CE. The first check (thermal warning) occurs when the CE operating temperature in a logic gate is 122°F but less than 134°F, or when the operating temperature in a PDU is 130°F but less than 140°F. The logic gate and PDU thermal warning sensing devices control relays K2–K4, K9, and K14–K17 (Figure 2-12).

When a thermal warning condition exists in any logic gate or in either PDU, the associated thermal warning relay is dropped. The realted thermal indicator on the maintenance panel is turned on, the THERMAL indicator on the CE control panel is turned on, a 24V dc signal is routed to the POWER CHECK indicator on the console, and relay K5 (OTC) is picked. When K5 picks, an OTC check signal is applied to the CE logic circuits, causing an external interrupt which informs the program. Note that a thermal condition does not cause a power-check indication at the CE nor does it initiate a power-off sequence.

The second check (thermal catastrophic) occurs when the operating temperature in a CE logic gate is more than 134°F or when the operating temperature in a PDU is more than 140°F. The CPU logic gate and PDU thermal catastrophic sensors control relay K24 (catastrophic thermal condition). When a catastrophic thermal condition occurs in either a logic gate or a PDU, the respective thermal catastrophic relay is dropped. The N/C contacts of K24 turn on the THERMAL indicator on the CE control panel, provide a 24V dc signal to the POWER CHECK indicator on the console, and pick relay K24 (initiate power-off sequence). Relay K29 now initiates a power down sequence by dropping the 6VNM supply. The power-off sequence turns on the CE POWER CHECK indicator through the K8 N/C points. After power has sequenced off, K13 (power on/off) remains picked because the POWER ON/OFF switches are still on.

To restore power to the CE, the thermal condition must be reset and the POWER ON/OFF switch must be turned off and then on. A THERMAL RESET pushbutton is provided to reset the thermal relays. When THERMAL RESET is pressed after the temperature in the overheated unit(s) has fallen below the warning level, the associated thermal relay picks, causing the related thermal indicator to be turned off. If a thermal condition is not reset before turning the POWER ON/OFF switch on again, power will not sequence up because the pick for relay K12 (start sequence time delay) and K13 (power on/off) is through the N/C point of K5 (OTC), which would still be picked if the thermal condition still exists.

In all catastrophic thermal conditions, the K27 (line sense and switching circuit conditioner) N/O points decondition the line sense and switching circuit to prevent the battery backup supply from sustaining power for an additional period of time.

Sequence Interlock Power-Off Sequence

- Power is automatically sequenced off if all voltages are not sequenced up within a specific period of time.
- Battery backup is deconditioned during a sequence interlock condition.

Power in the CE should completely sequence up within approximately 5 seconds after K12 (start sequence time delay) has transferred. If, for some reason, one or more of the regulators fails to operate, power is automatically sequenced off. This automatic power-off sequence is accomplished by K30 (sequence interlock time delay), which transfers 5 seconds after being energized.

If the power sequence is completed before K30 picks, a hold circuit is established for PK2 (ac on) through the K8 (sequence complete) N/O points. If the power sequence is not complete before K30 picks, this hold circuit is not yet established, and the N/C points of K30 open the pick circuit for PK2, causing power to sequence off.

To start another power-on sequence, the POWER ON/OFF switch must be turned off then on. Because K27 was never dropped, the line sense and switching circuit remains deconditioned, and the battery backup supply is prevented from sustaining power.

48V Overvoltage/Overcurrent Condition

The 48V supply, like all other regulators in the CE, has an OV/OC sense relay. If an OV/OC condition occurs in this supply (Figure 2-23), its sense relay (a reed relay on the OV/OC SMS card) is picked. The N/O contacts of the picked reed relay (Figure 2-12) pick K18 (48V power

check). When K18 picks, it holds itself through its own N/O points, drops contactor PK6 (48V supply disconnect), turns on the POWER CHECK indicators, and sends the 'power check' signal to the console.

When PK6 drops, it cuts off the 2500-Hz input power to the 48V supply. The CE then remains in this status until the OV/OC condition is reset.

The CE does not drop any power other than the 48V supply when an OV/OC condition occurs in the 48V supply, and the only indications of a 48V check are the POWER CHECK indicators being on.

To restore power to the +48V supply after an OV/OC condition, the 48V OV/OC RESET pushbutton on the maintenance panel must be pressed for 2 seconds or longer. Pressing this button drops the reed relay on the 48V supply OV/OC SMS card by opening the 25V dc bias supply voltage from the C/I to this card (power logic YA141). Pressing 48V OV/OC RESET also starts the 2-second time delay relay A–K1 timing out. When A–K1 times out (2 seconds elapsed), its N/C points open and drop K18 (48V power check). The 2-second delay on A–K1 is the reason 48V OV/OC RESET must be held for at least 2 seconds.

When K18 drops, it drops A–K1, turns off the POWER CHECK indicators, and drops the 'power check' line to the console. The K18 N/C points provide a pick circuit for PK6 (48V supply disconnect) through the A–K1 N/C points. When PK6 picks, it applies 2500-Hz input power from the C/I to the +48V supply, and the +48V supply begins producing +48V dc once again.

CONTROLS AND INDICATORS

The following controls and indicators are associated with CE power. Controls and indicators described here are on the CE control panel, the maintenance panel, and the prime power box. These three areas are described separately. Controls and indicators on the regulators and converter/inverter are described in Solid Logic Technology Power Supplies, FEMI.

CE Control Panel

The controls and indicators associated with CE power are on the upper left and lower right sections of the panel. The ELEMENT MPO PULL switch is on the upper right corner of the panel.

ELEMENT MPO PULL Switch

Pulling the ELEMENT MPO PULL switch causes all CE power to be removed within 2 seconds. However, power is still present at the CE entry terminal and at the 24V prime power supply.

Note: The ELEMENT MPO PULL switch is a mechanical latch-type switch that must be reset manually. After the switch is reset, power automatically sequences up if the POWER ON/OFF switches are set to ON.

POWER ON/OFF Switch

The POWER ON/OFF switch begins the power on/off sequence for the CE. After the completion of a power-on sequence, this switch is effective only when the CE is in state zero and in test condition. The POWER ON/OFF switch is connected in series with the maintenance panel POWER ON/OFF switch.

POWER SEQUENCE COMPLETE Indicator

The POWER SEQUENCE COMPLETE indicator lights when the power sequence in the CE is complete. This indicator is turned off when the first power supply (+6VNM) is sequenced off during a power-down operation.

CE POWER STATUS Indicators

The four CE POWER STATUS indicators function as follows:

MAINLINE ON: Is on when prime power is available. This indicator is independent of the POWER ON/OFF switches.

OBS: Is on when the CE is operating on battery power.

THERMAL: Is on when the upper limit (warning or catastrophic) temperature is exceeded in the CE.

POWER CHECK: Is on when one or more of the following conditions exist in the CE power system:

1. A catastrophic power failure has occurred (OV/OC), UV, or sequence interlock condition).
2. A catastrophic thermal condition has sequenced power off.
3. A normal power-off operation has occurred.

STATE Indicators

The four STATE indicators reflect the operational state of the element (state three, two, one, or zero). The CE must be in state zero before a normal power-off sequence can begin.

TEST Switch

The TEST switch is effective when the CE is in state zero. This switch must be on before a normal power-off sequence can begin.

Voltmeter

The voltmeter monitors the selected marginal voltage.

MARGIN/METER SEL Rotary Switch

The MARGIN/METER SEL switch selects the marginal voltage to be monitored on the meter. The SEL position of this switch is also used in conjunction with the LOCATE indicator to determine which supply is being margined.

Marginal Voltage Control Potentiometers

The marginal voltage control potentiometers allow the marginal power supplies to be varied above and below their nominal values. More than one voltage can be varied at one time. The variable (marginal) supplies are:

Reg	Location	Voltage	Load
7	01A	+6M	E Gate
8	01A	+6M	C and D Gate
11	01C	-18V	ROS
15	01C	+6M	B Gate
16	01C	+6M	A Gate
5	02G	+6M	K and L Gates

MARGIN Indicators

The two MARGIN indicators function as follows:

ACTIVE: Is lit whenever one or more of the marginal voltage potentiometers is adjusted away from its nominal value.

LOCATE: Is used in conjunction with the MARGIN/METER SEL rotary switch. It lights only if the MARGIN/METER SEL switch is turned to the position of a supply that is adjusted away from its nominal value by its marginal voltage control potentiometer.

Maintenance Panel

The controls and indicators located on the maintenance panel are used primarily for maintenance and trouble-shooting rather than operation of the CE.

THERMAL Indicators

There are eight thermal indicators on the maintenance panel. A thermal indicator is lit whenever its respective area has a thermal warning condition. These areas are:

1. GATE A
2. GATE B
3. GATE C/D
4. GATE E
5. GATE K
6. GATE L
7. PWR PDU I
8. PWR PDU II

Sequence Complete (SEQ COMP), Power Check (PWR CHK), and On Battery (ON BAT) Indicators

These indicators perform the same functions as their corresponding indicators on the CE control panel previously described.

POWER ON/OFF Switch

This switch performs the same functions as the POWER ON/OFF switch on the CE control panel previously described. These two POWER ON/OFF switches are connected in series, so both must be turned on to power on the CE.

TEST OBS Pushbutton

Pressing TEST OBS simulates an on-battery condition by forcing an 'on battery' signal into the CE logic circuit. This signal is set into the DAR register where the program can test for this condition.

TEST OTC Pushbutton

Pressing TEST OTC simulates a thermal warning condition in the CE by forcing an OTC check into the CE logic circuit. This signal is transmitted into the DAR register where the program can test for this condition.

THERMAL RESET Pushbutton

Pressing THERMAL RESET resets the thermal relays that are controlled by the thermal sensing elements within the logic and PDU frames. Activation of this pushbutton also turns off the THERMAL CHECK indicator if the related frame temperature has fallen below the warning level.

48V OV/OC RESET Pushbutton

Pressing 48V OV/OC RESET resets the 48V power check relay on the 01B relay gate if the OV/OC condition has been removed from the +48V supply.

When the 48V power check relay (K18) drops, it turns off the POWER CHECK indicators and drops the 'power check' line to the console.

Undervoltage Check Switches

Undervoltage check switches provide a means of locating a defective regulator that is causing an undervoltage condition. The switch labels relate each switch to its power supply regulator. If the switch is set to OFF, undervoltage detection of its associated regulator is prevented.

Prime Power Box

The prime power box controls are circuit breakers and fuses.

Circuit Breakers

CB1 (Mainline Circuit Breaker): controls the 3-phase, 208V ac, 60-Hz input to the CE from the facility ac service.

CB2: controls input to the ±20V dc prime voltage sense supply and to the transformer which supplies 12.6V ac to the interval timer circuits within the CE logic circuits.

CB7: controls input to the transformer that supplies 28V ac prime to the C/I control circuits.

CB8: controls inputs to all fans and blowers in the CE except the fan in the C/I.

CB9: controls input power to the line sense and battery charger unit and to the C/I and its fan.

CB11: controls 115V ac power to the convenience outlets in the CE.

CB12: controls 208V ac power to the console, to the stepdown transformer which supplies 115V ac to the convenience outlets, and the 115V ac to the console keyboard printer.

Fuses

Fuses F1 and F2: protect the +24V prime power supply and its associated circuits from overload.

Fuse F3: protects the inputs to the prime 28V ac supply, the ±20V prime voltage sense supply, and the transformer which supplies 12.6V ac to the interval timer.

Fuse F4: protects the 115V ac line going to the keyboard printer.

Fuses F5 and F6: protect the 208V ac line going to the console.

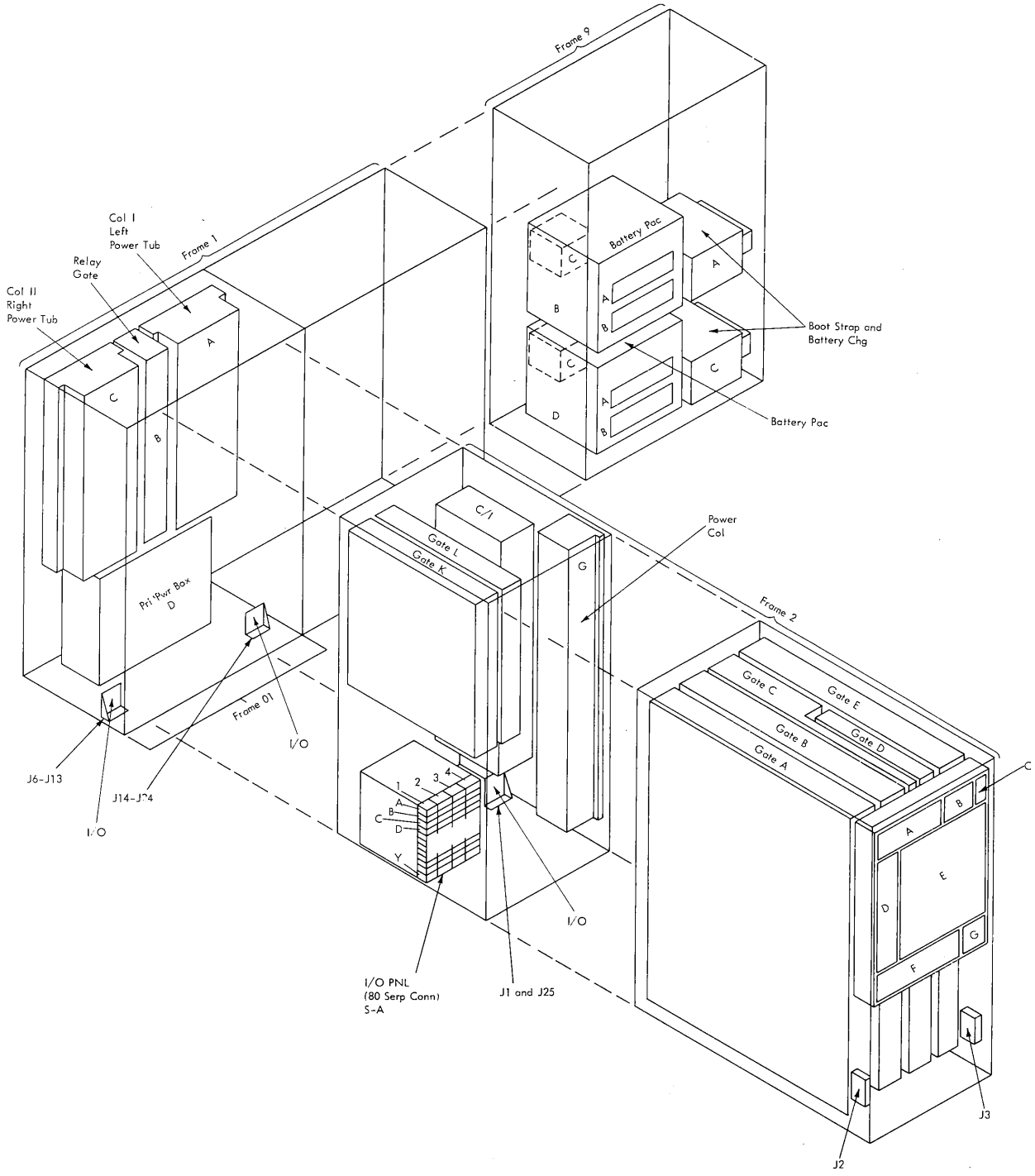


Figure 2-1. CE Power Assemblies

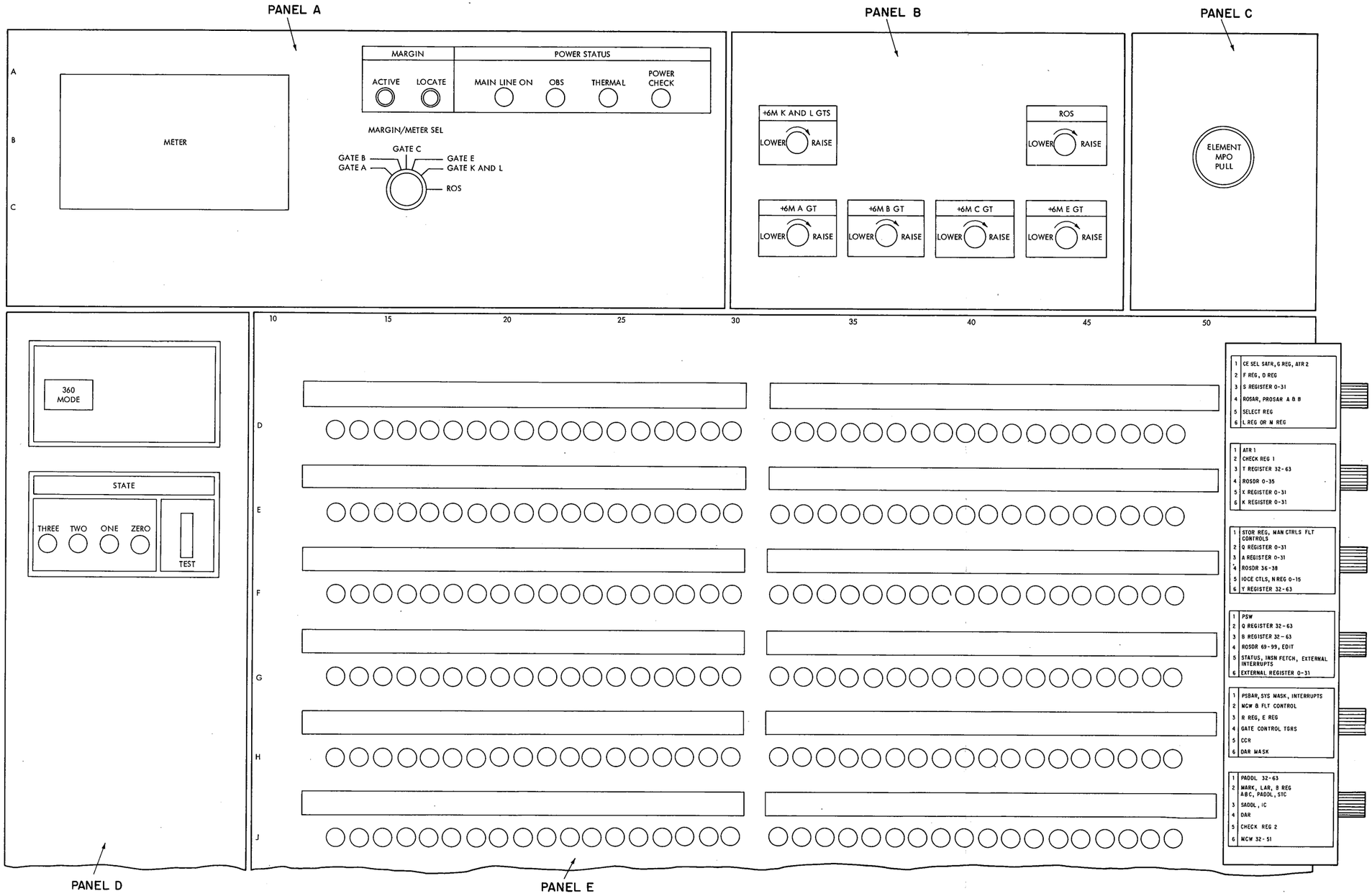


Figure 2-2. CE Control Panel (Sheet 1 of 2)

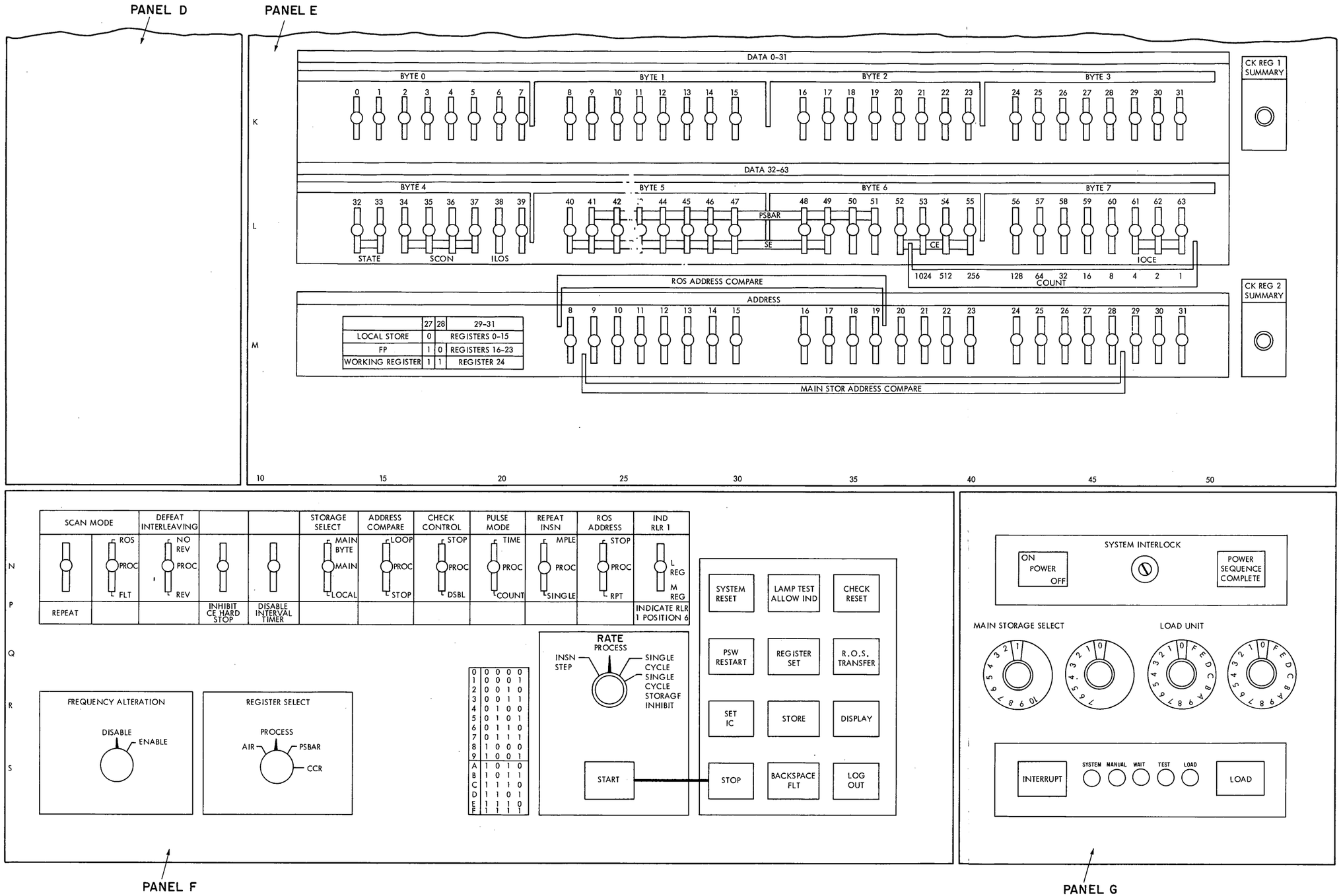
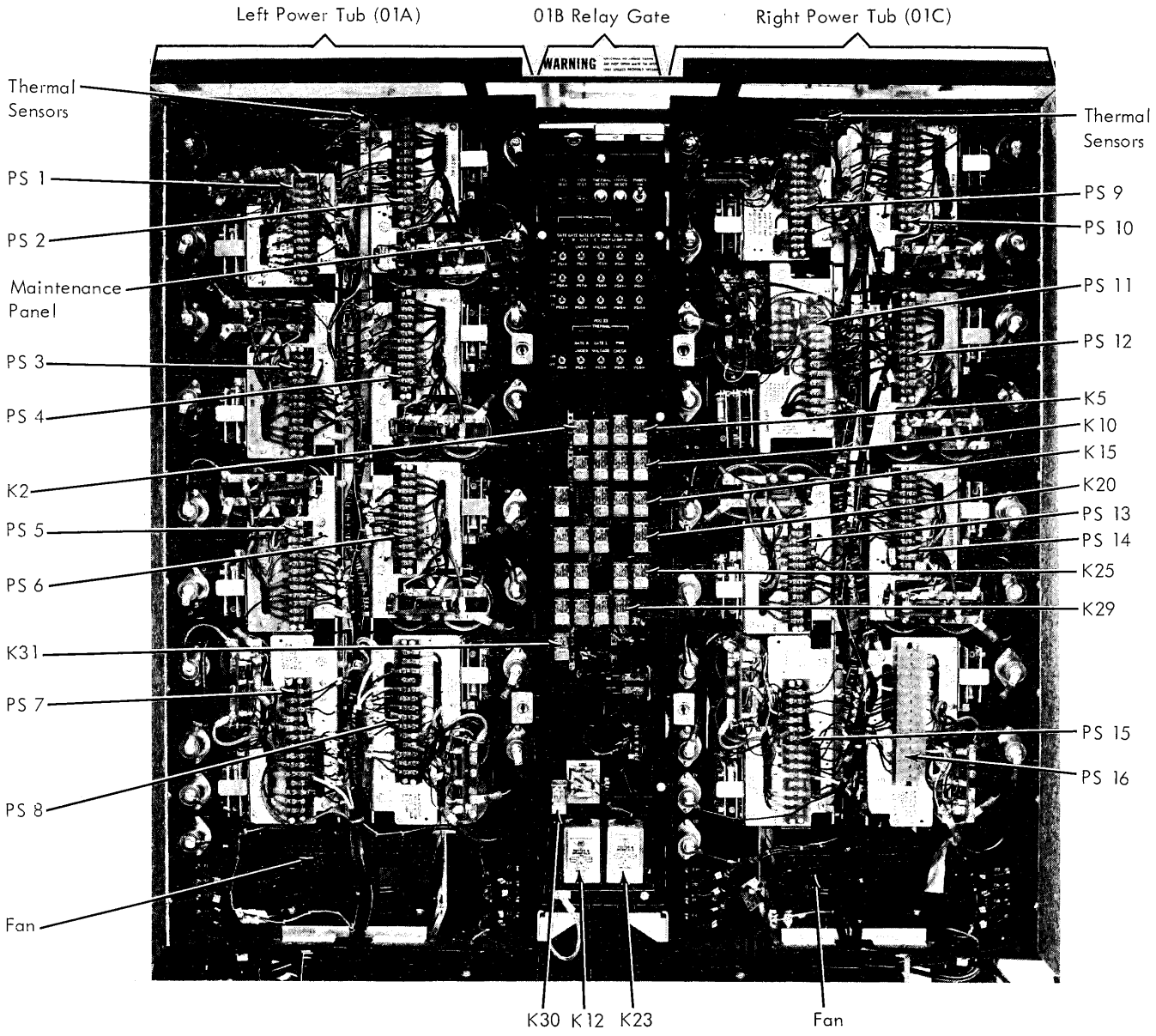


Figure 2-2. CE Control Panel (Sheet 2 of 2)



● Figure 2-3. PDU 1 Power Components

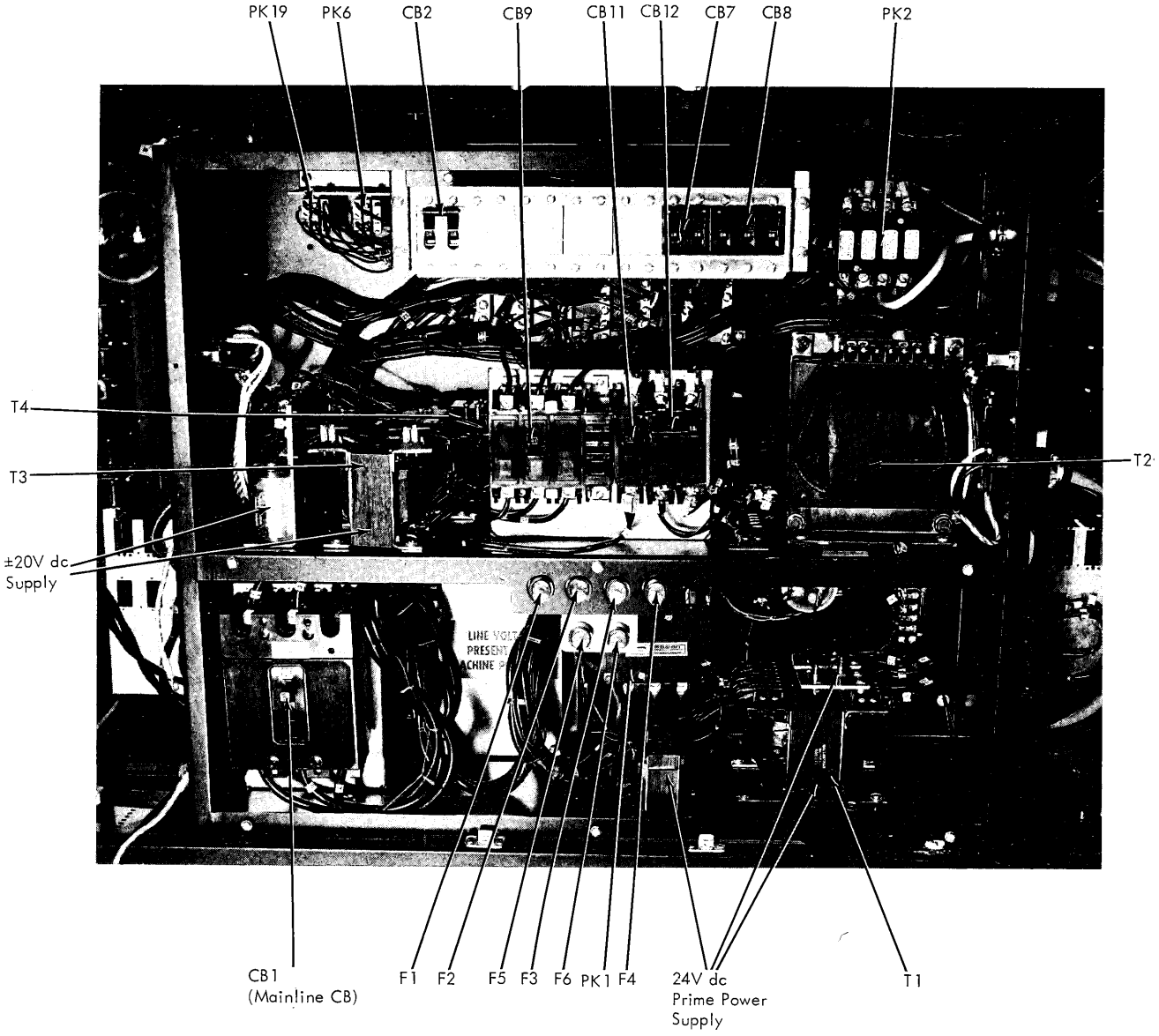


Figure 2-4. Prime Power Box

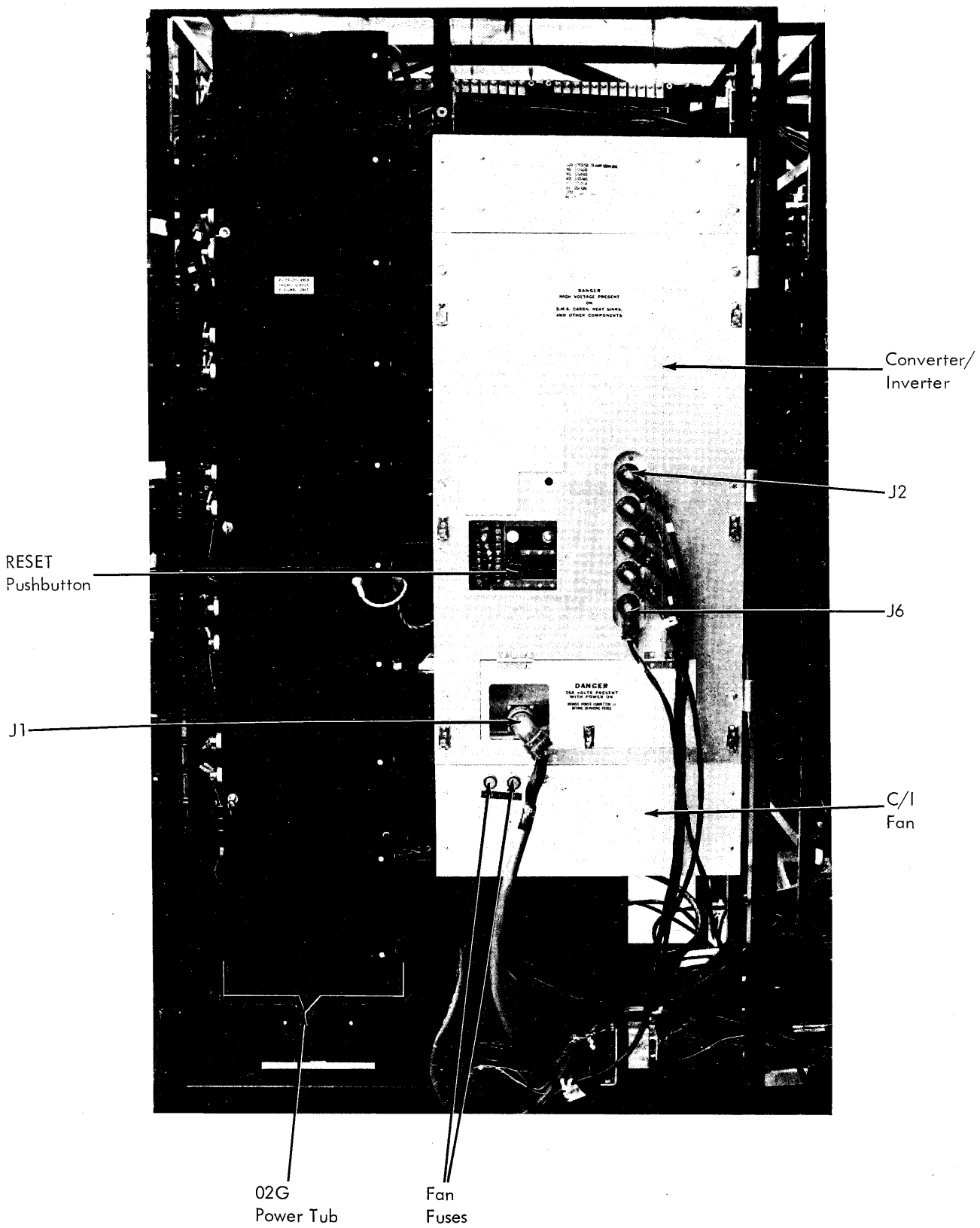


Figure 2-5. PDU 2 Power Components

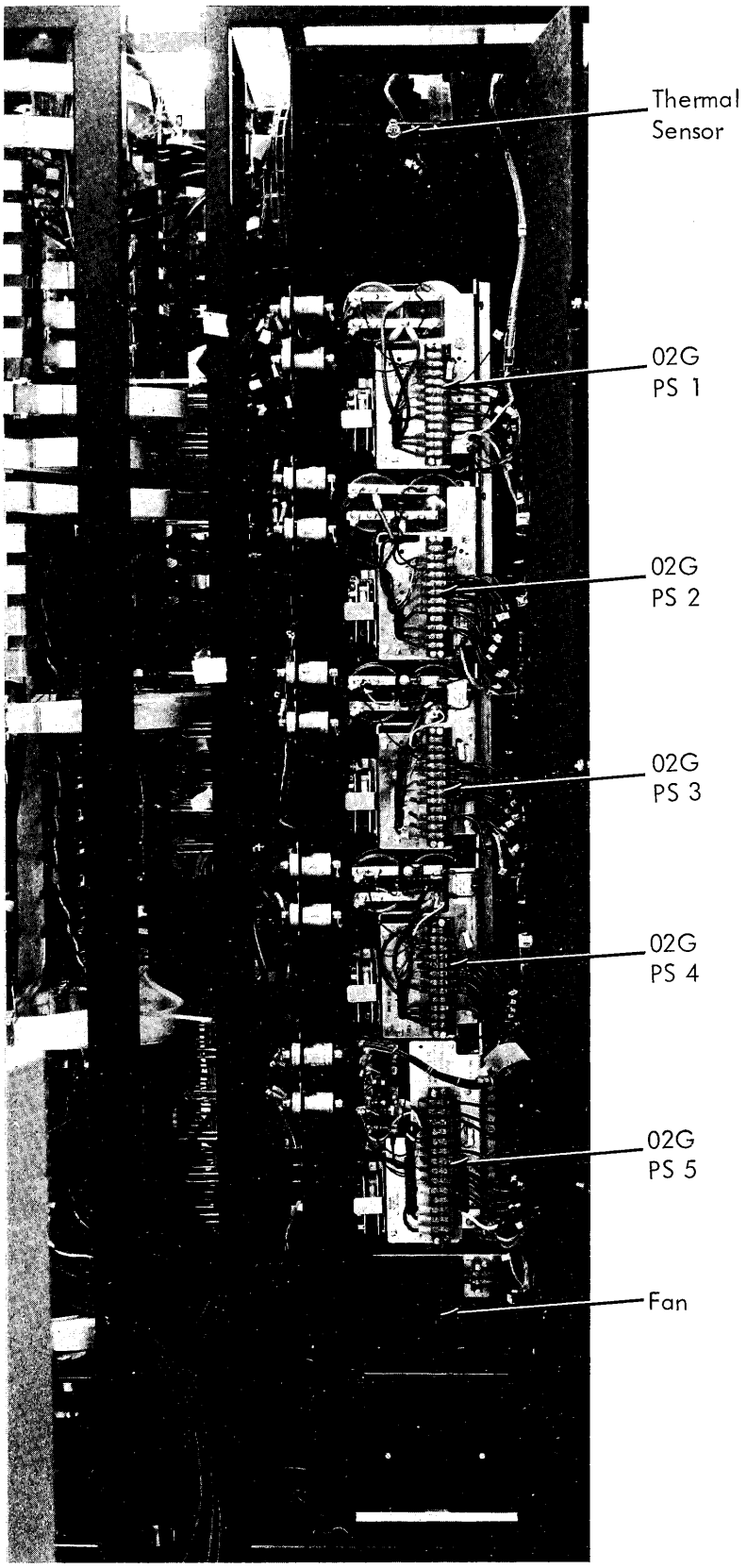


Figure 2-6. Power Tub (02G)

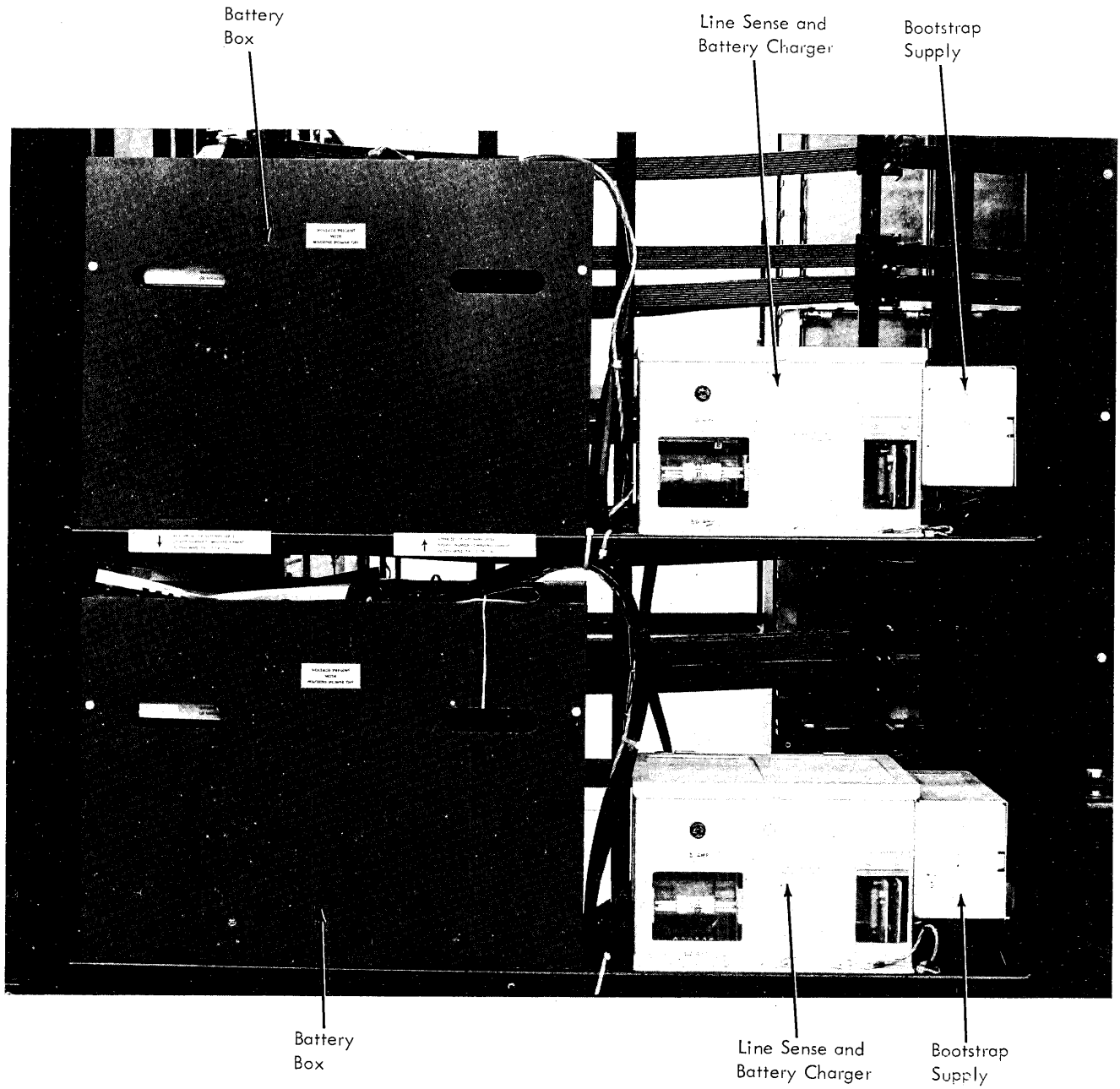


Figure 2-7. Battery Backup Power Compartment

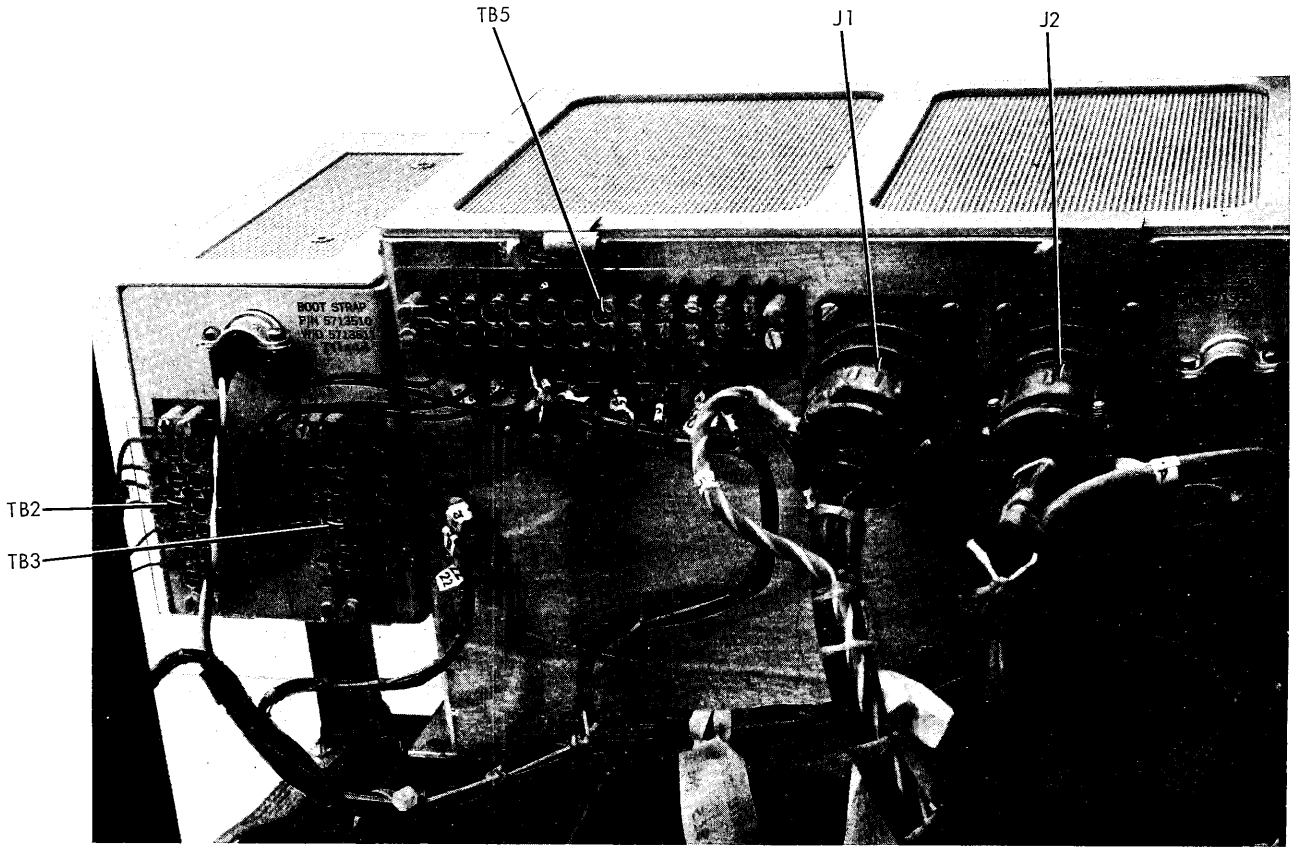


Figure 2-8. Line Sense, Battery Charger, and Bootstrap Supply

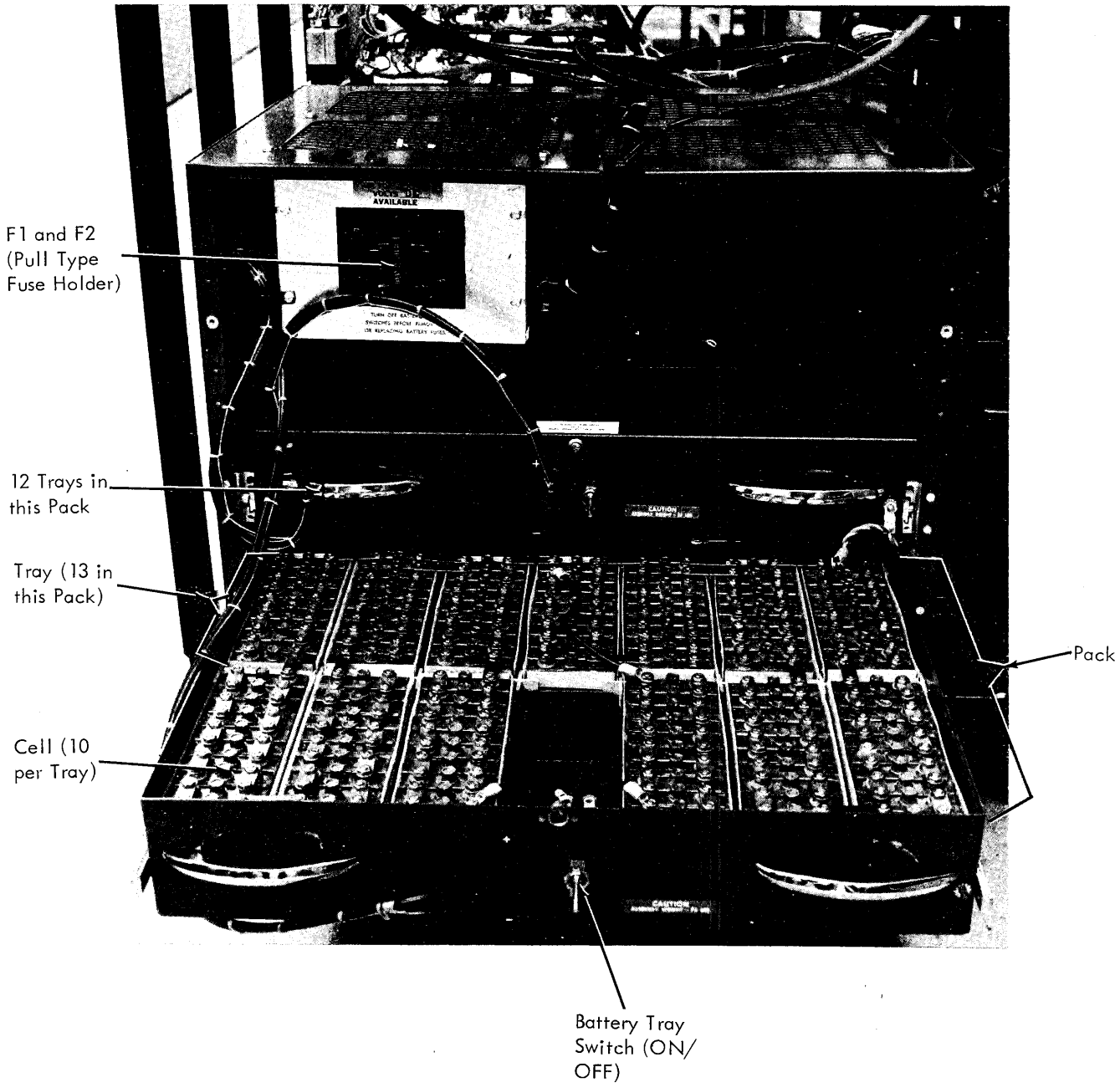


Figure 2-9. Battery Box

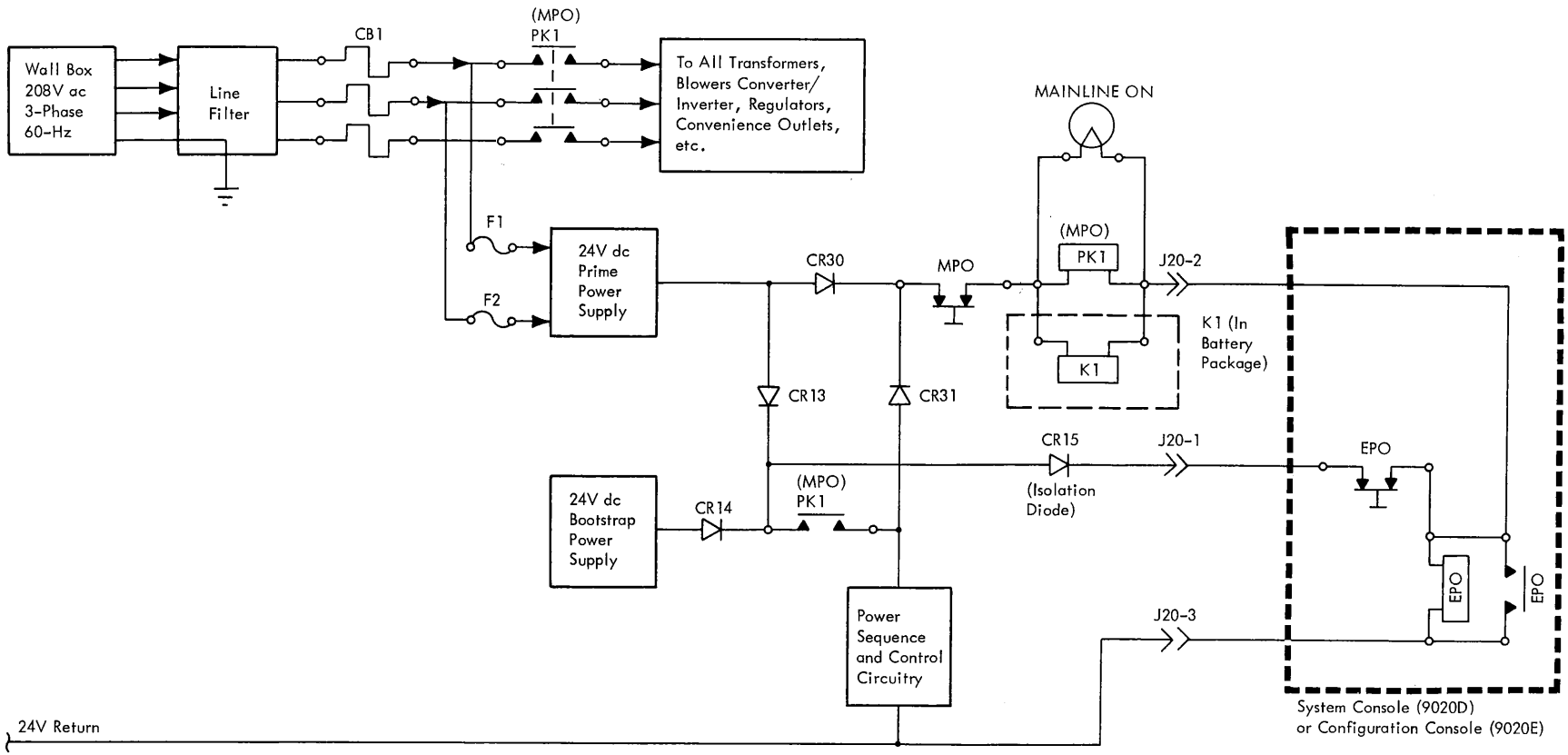


Figure 2-10. CE Power Interlock Circuitry

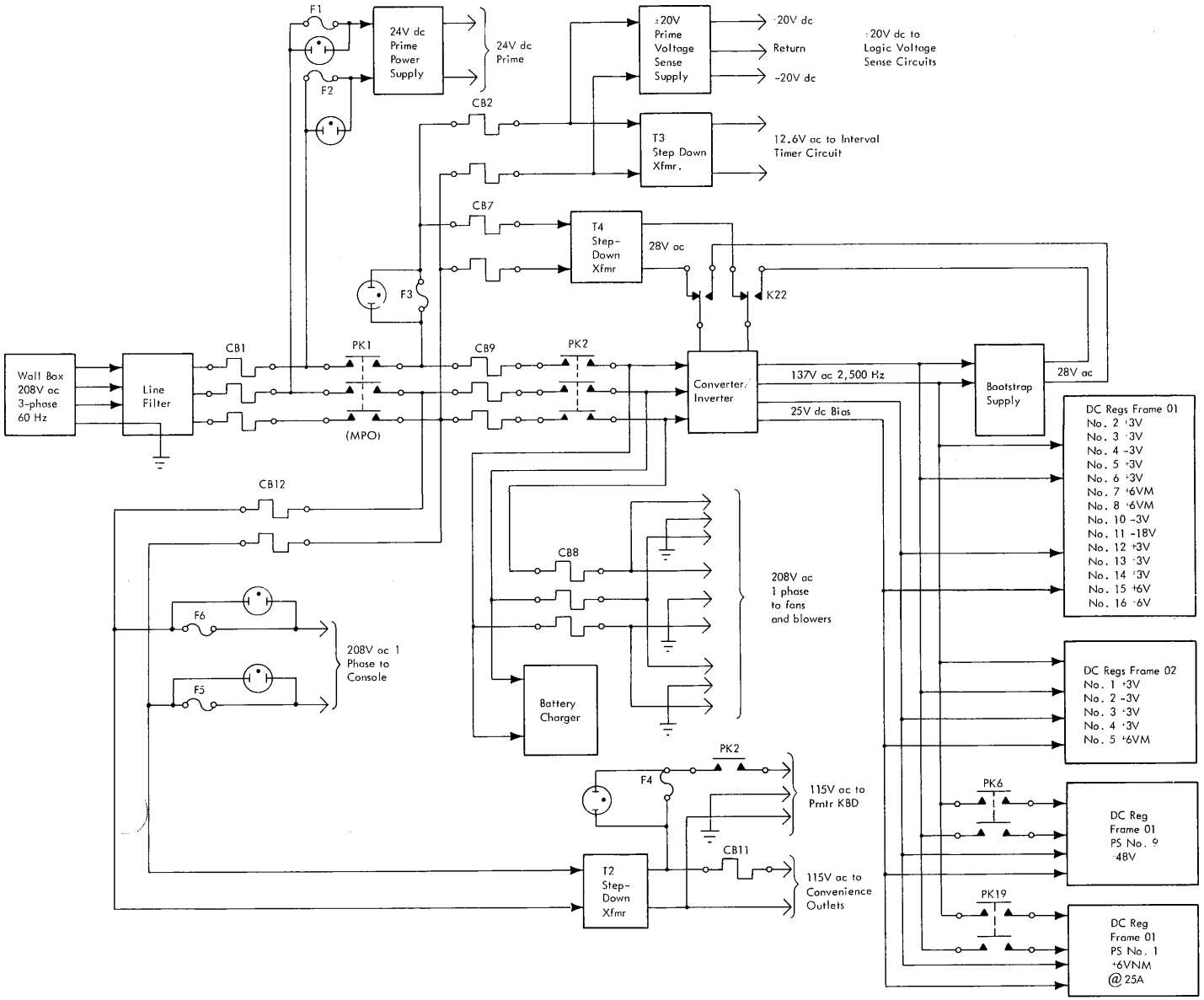
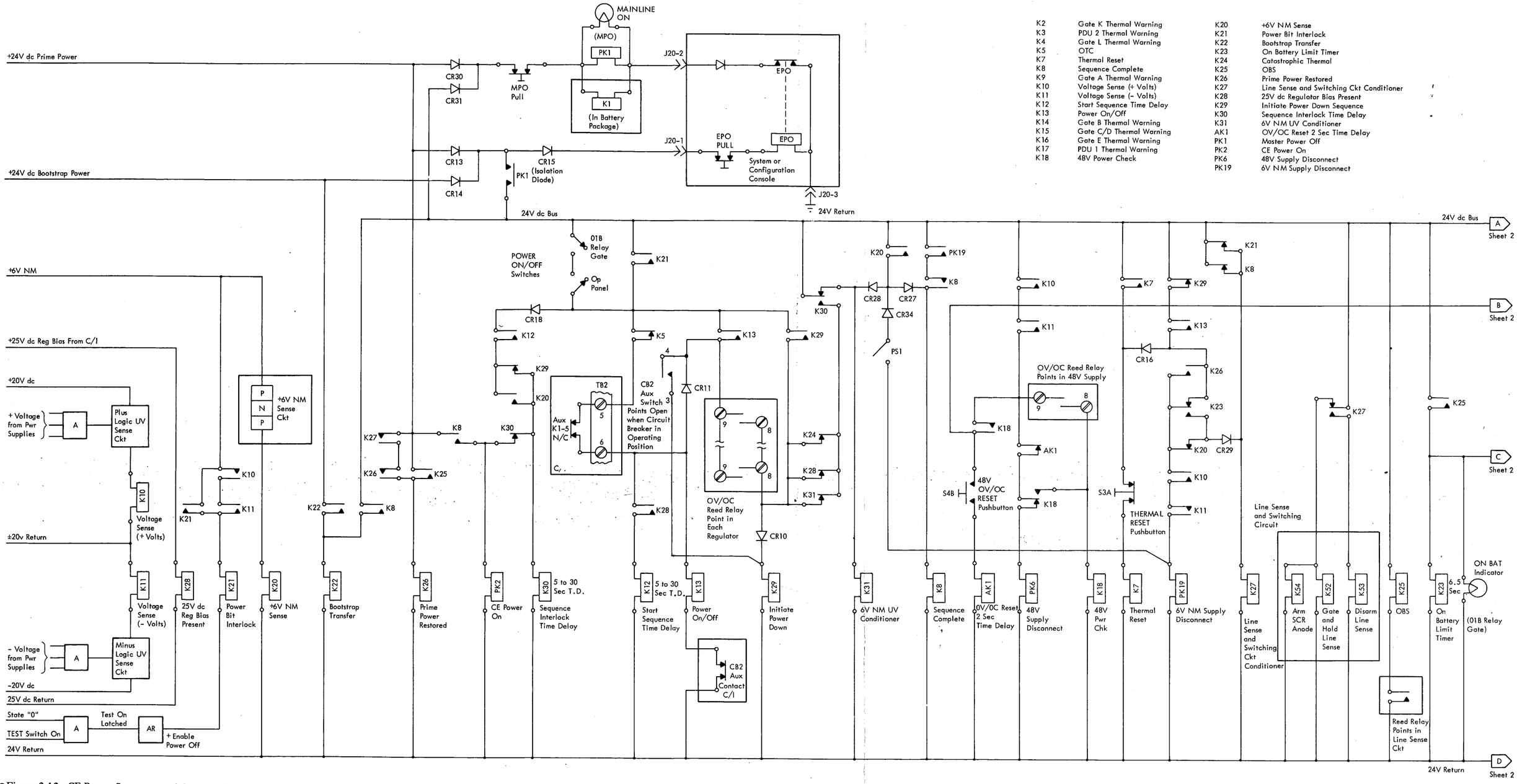
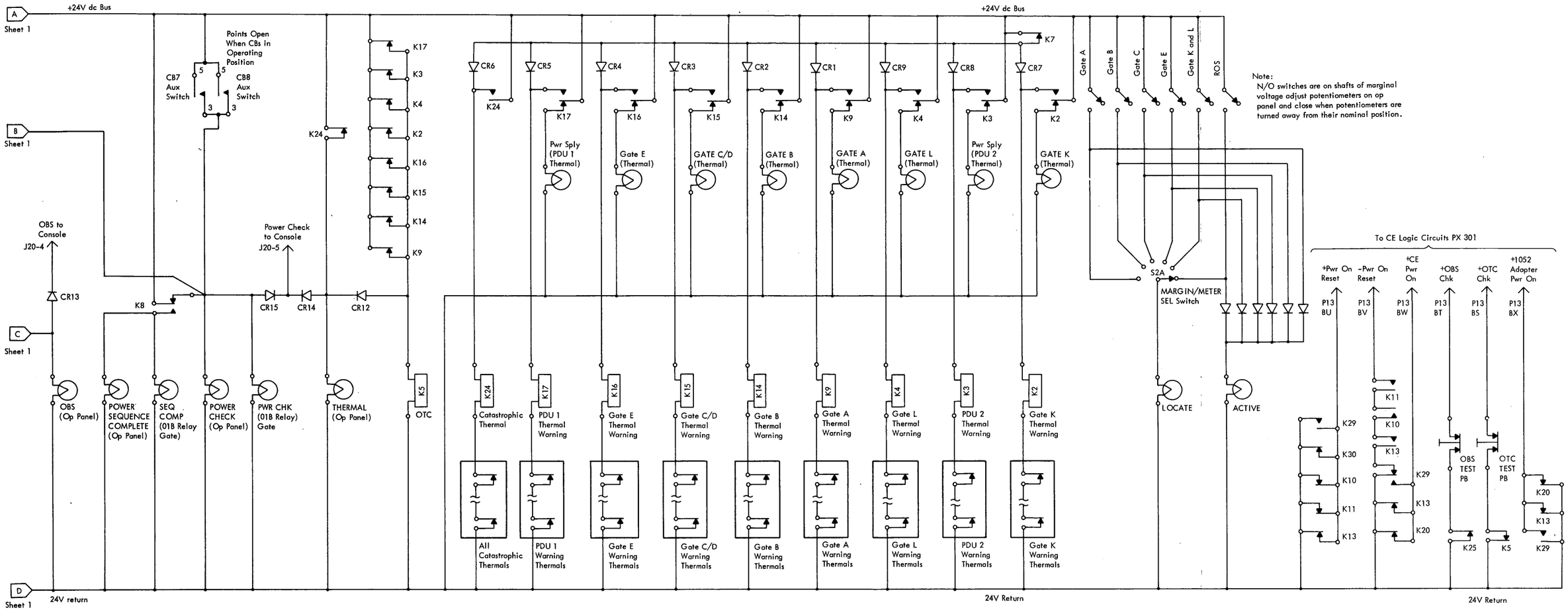


Figure 2-11. CE AC Distribution



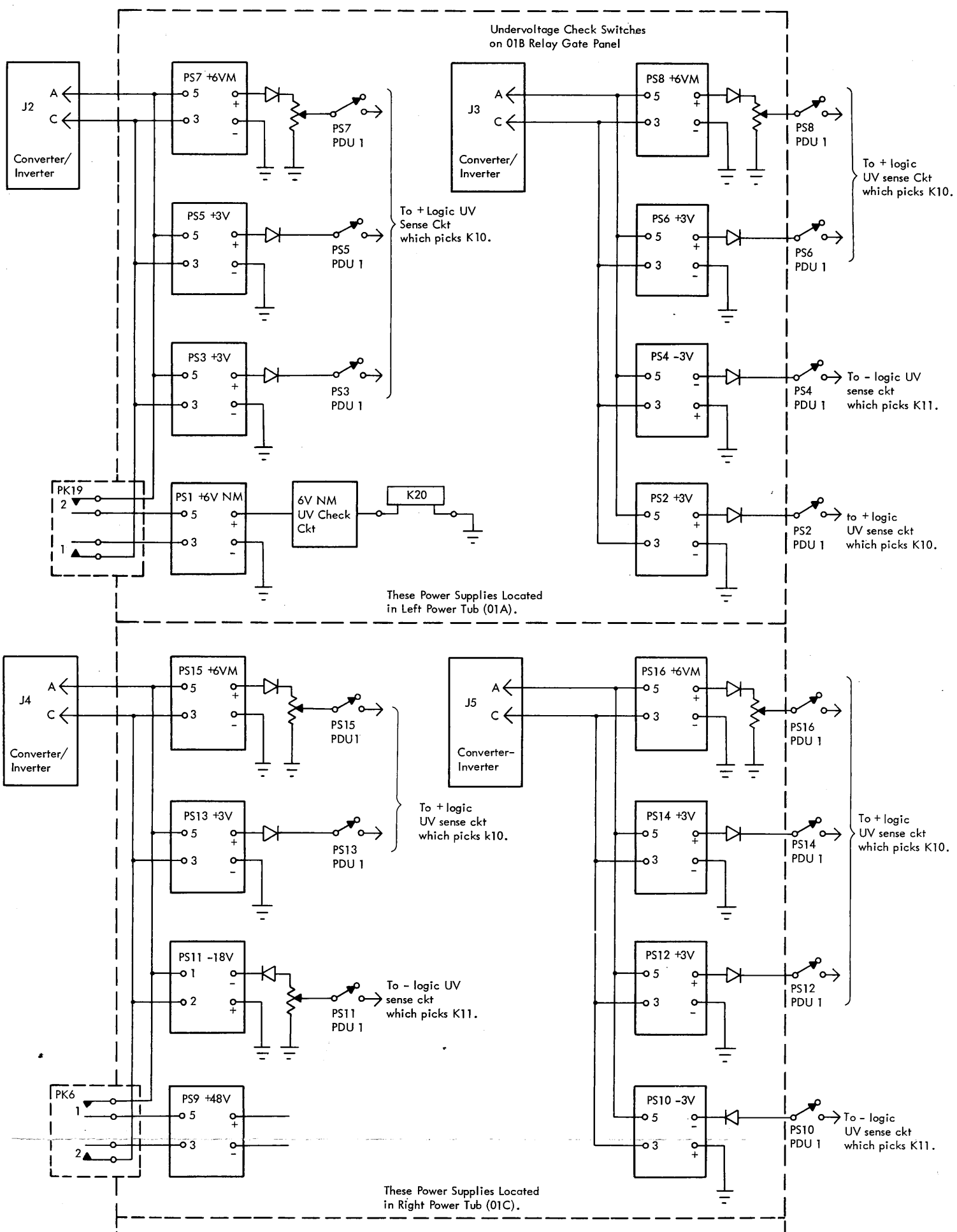
K2	Gate K Thermal Warning	K20	+6V NM Sense
K3	PDU 2 Thermal Warning	K21	Power Bit Interlock
K4	Gate L Thermal Warning	K22	Bootstrap Transfer
K5	OTC	K23	On Battery Limit Timer
K7	Thermal Reset	K24	Catastrophic Thermal
K8	Sequence Complete	K25	OBS
K9	Gate A Thermal Warning	K26	Prime Power Restored
K10	Voltage Sense (+ Volts)	K27	Line Sense and Switching Ckt Conditioner
K11	Voltage Sense (- Volts)	K28	25V dc Regulator Bias Present
K12	Start Sequence Time Delay	K29	Initiate Power Down Sequence
K13	Power On/Off	K30	Sequence Interlock Time Delay
K14	Gate B Thermal Warning	K31	6V NM UV Conditioner
K15	Gate C/D Thermal Warning	AK1	OV/OC Reset 2 Sec Time Delay
K16	Gate E Thermal Warning	PK1	Master Power Off
K17	PDU 1 Thermal Warning	PK2	CE Power On
K18	48V Power Check	PK6	48V Supply Disconnect
		PK19	6V NM Supply Disconnect

●Figure 2-12. CE Power Sequence and Control Circuitry (Sheet 1 of 2)



K2	Gate K Thermal Warning	K20	+6V NM Sense
K3	PDU 2 Thermal Warning	K21	Power Bit Interlock
K4	Gate L Thermal Warning	K22	Bootstrap Transfer
K5	OTC	K23	On Battery Limit Timer
K7	Thermal Reset	K24	Catastrophic Thermal
K8	Sequence Complete	K25	OBS
K9	Gate A Thermal Warning	K26	Prime Power Restored
K10	Voltage Sense (+ Volts)	K27	Line Sense and Switching Ckt Conditioner
K11	Voltage Sense (- Volts)	K28	25V dc Regulator Bias Present
K12	Start Sequence Time Delay	K29	Initiate Power Down Sequence
K13	Power On/Off	K30	Sequence Interlock Time Delay
K14	Gate B Thermal Warning	K31	6V NM UV Conditioner
K15	Gate C/D Thermal Warning	AK1	OV/OC Reset 2 Sec Time Delay
K16	Gate E Thermal Warning	PK1	Master Power Off
K17	PDU 1 Thermal Warning	PK2	CE Power On
K18	48V Power Check	PK6	48V Supply Disconnect
		PK19	6V NM Supply Disconnect

●Figure 2-12. CE Power Sequence and Control Circuitry (Sheet 2 of 2)



●Figure 2-13. DC Regulators

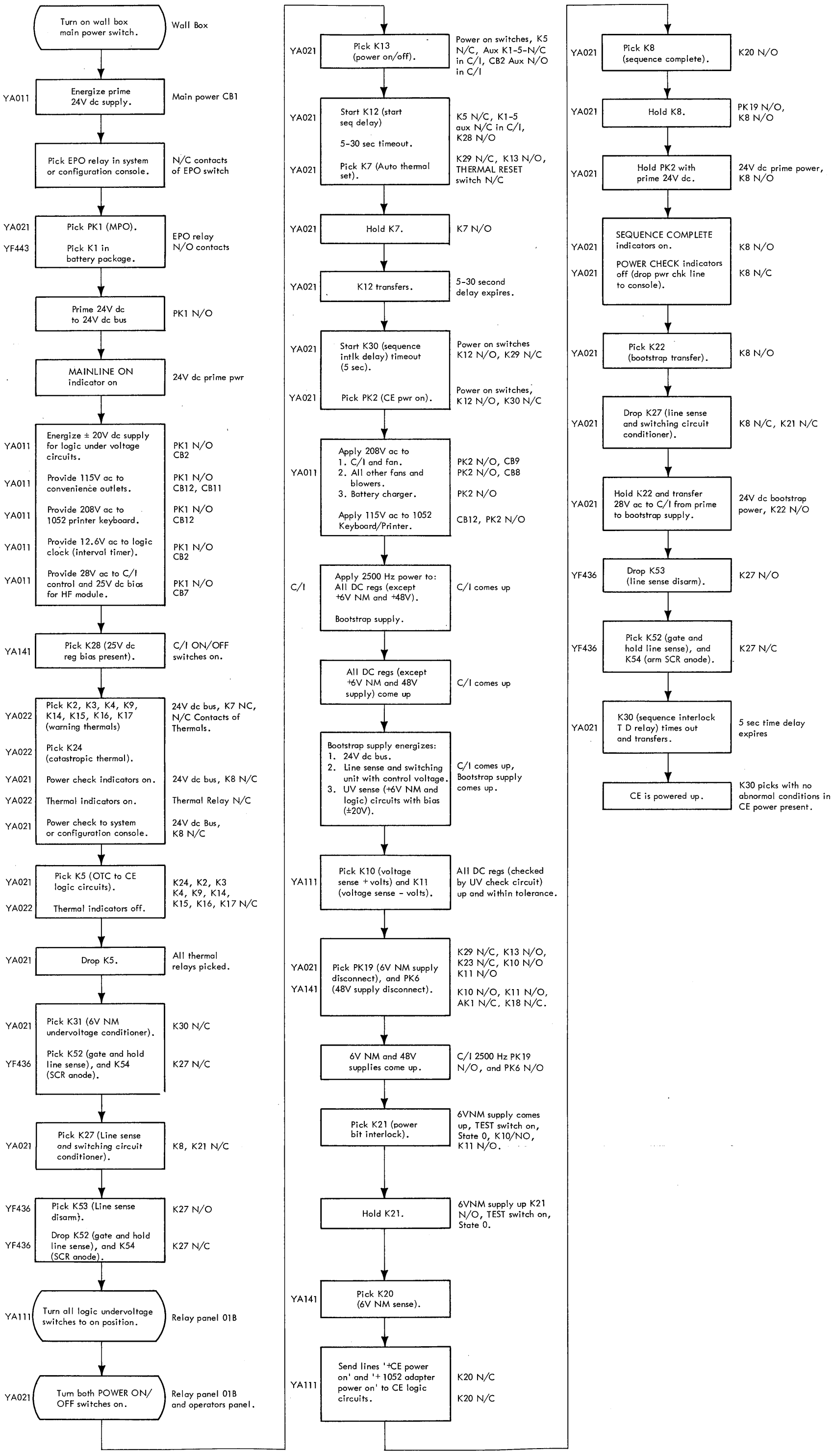

Turn on wall box main power switch.
Wall Box
YA011
Energize prime 24V dc supply.
Main power CB1
Pick EPO relay in system or configuration console.
N/C contacts of EPO switch
YA021
YF443
Pick PK1 (MPO).
Pick K1 in battery package.
EPO relay N/O contacts
Prime 24V dc to 24V dc bus
PK1 N/O
MAINLINE ON indicator on
24V dc prime pwr
YA011
Energize ± 20V dc supply for logic under voltage circuits.
PK1 N/O CB2
YA011
Provide 115V ac to convenience outlets.
PK1 N/O CB12, CB11
YA011
Provide 208V ac to 1052 printer keyboard.
PK1 N/O CB12
YA011
Provide 12.6V ac to logic clock (interval timer).
PK1 N/O CB2
YA011
Provide 28V ac to C/I control and 25V dc bias for HF module.
PK1 N/O CB7
YA141
Pick K28 (25V dc reg bias present).
C/I ON/OFF switches on.
YA022
Pick K2, K3, K4, K9, K14, K15, K16, K17 (warning thermals)
24V dc bus, K7 NC, N/C Contacts of Thermals.
YA022
Pick K24 (catastropic thermal).
YA021
Power check indicators on.
24V dc bus, K8 N/C
YA022
Thermal indicators on.
Thermal Relay N/C
YA021
Power check to system or configuration console.
24V dc Bus, K8 N/C
YA021
Pick K5 (OTC to CE logic circuits).
YA022
Thermal indicators off.
K24, K2, K3 K4, K9, K14, K15, K16, K17 N/C
YA021
Drop K5.
All thermal relays picked.
YA021
Pick K31 (6V NM undervoltage conditioner).
K30 N/C
YF436
Pick K52 (gate and hold line sense), and K54 (SCR anode).
K27 N/C
YA021
Pick K27 (Line sense and switching circuit conditioner).
K8, K21 N/C
YF436
Pick K53 (Line sense disarm).
K27 N/O
YF436
Drop K52 (gate and hold line sense), and K54 (SCR anode).
K27 N/C
YA111
Turn all logic undervoltage switches to on position.
Relay panel 01B
YA021
Turn both POWER ON/ OFF switches on.
Relay panel 01B and operators panel.
YA021
Pick K13 (power on/off).
Power on switches, K5 N/C, Aux K1-5-N/C in C/I, CB2 Aux N/O in C/I
YA021
Start K12 (start seq delay)
5-30 sec timeout.
K5 N/C, K1-5 aux N/C in C/I, K28 N/O
YA021
Pick K7 (Auto thermal set).
K29 N/C, K13 N/O, THERMAL RESET switch N/C
YA021
Hold K7.
K7 N/O
YA021
K12 transfers.
5-30 second delay expires.
YA021
Start K30 (sequence intlk delay) timeout (5 sec).
Power on switches K12 N/O, K29 N/C
YA021
Pick PK2 (CE pwr on).
Power on switches, K12 N/O, K30 N/C
YA011
Apply 208V ac to
1. C/I and fan.
2. All other fans and blowers.
3. Battery charger.
Apply 115V ac to 1052 Keyboard/Printer.
PK2 N/O, CB9
PK2 N/O, CB8
PK2 N/O
CB12, PK2 N/O
C/I
Apply 2500 Hz power to: All DC regs (except +6V NM and +48V).
Bootstrap supply.
C/I comes up
All DC regs (except +6V NM and 48V supply) come up
C/I comes up
Bootstrap supply energizes:
1. 24V dc bus.
2. Line sense and switching unit with control voltage.
3. UV sense (+6V NM and logic) circuits with bias (±20V).
C/I comes up, Bootstrap supply comes up.
YA111
Pick K10 (voltage sense + volts) and K11 (voltage sense - volts).
All DC regs (checked by UV check circuit) up and within tolerance.
YA021
YA141
Pick PK19 (6V NM supply disconnect), and PK6 (48V supply disconnect).
K29 N/C, K13 N/O, K23 N/C, K10 N/O K11 N/O
K10 N/O, K11 N/O, AK1 N/C, K18 N/C.
6V NM and 48V supplies come up.
C/I 2500 Hz PK19 N/O, and PK6 N/O
Pick K21 (power bit interlock).
6VNM supply comes up, TEST switch on, State 0, K10/NO, K11 N/O.
Hold K21.
6VNM supply up K21 N/O, TEST switch on, State 0.
YA141
Pick K20 (6V NM sense).
YA111
Send lines '+CE power on' and '+ 1052 adapter power on' to CE logic circuits.
K20 N/C
K20 N/C
YA021
Pick K8 (sequence complete).
K20 N/O
YA021
Hold K8.
PK19 N/O, K8 N/O
YA021
Hold PK2 with prime 24V dc.
24V dc prime power, K8 N/O
YA021
SEQUENCE COMPLETE indicators on.
K8 N/O
YA021
POWER CHECK indicators off (drop pwr chk line to console).
K8 N/C
YA021
Pick K22 (bootstrap transfer).
K8 N/O
YA021
Drop K27 (line sense and switching circuit conditioner).
K8 N/C, K21 N/C
YA021
Hold K22 and transfer 28V ac to C/I from prime to bootstrap supply.
24V dc bootstrap power, K22 N/O
YF436
Drop K53 (line sense disarm).
K27 N/O
YF436
Pick K52 (gate and hold line sense), and K54 (arm SCR anode).
K27 N/C
YA021
K30 (sequence interlock T D relay) times out and transfers.
5 sec time delay expires
CE is powered up.
K30 picks with no abnormal conditions in CE power present.

Figure 2-14. CE Power-On Flowchart

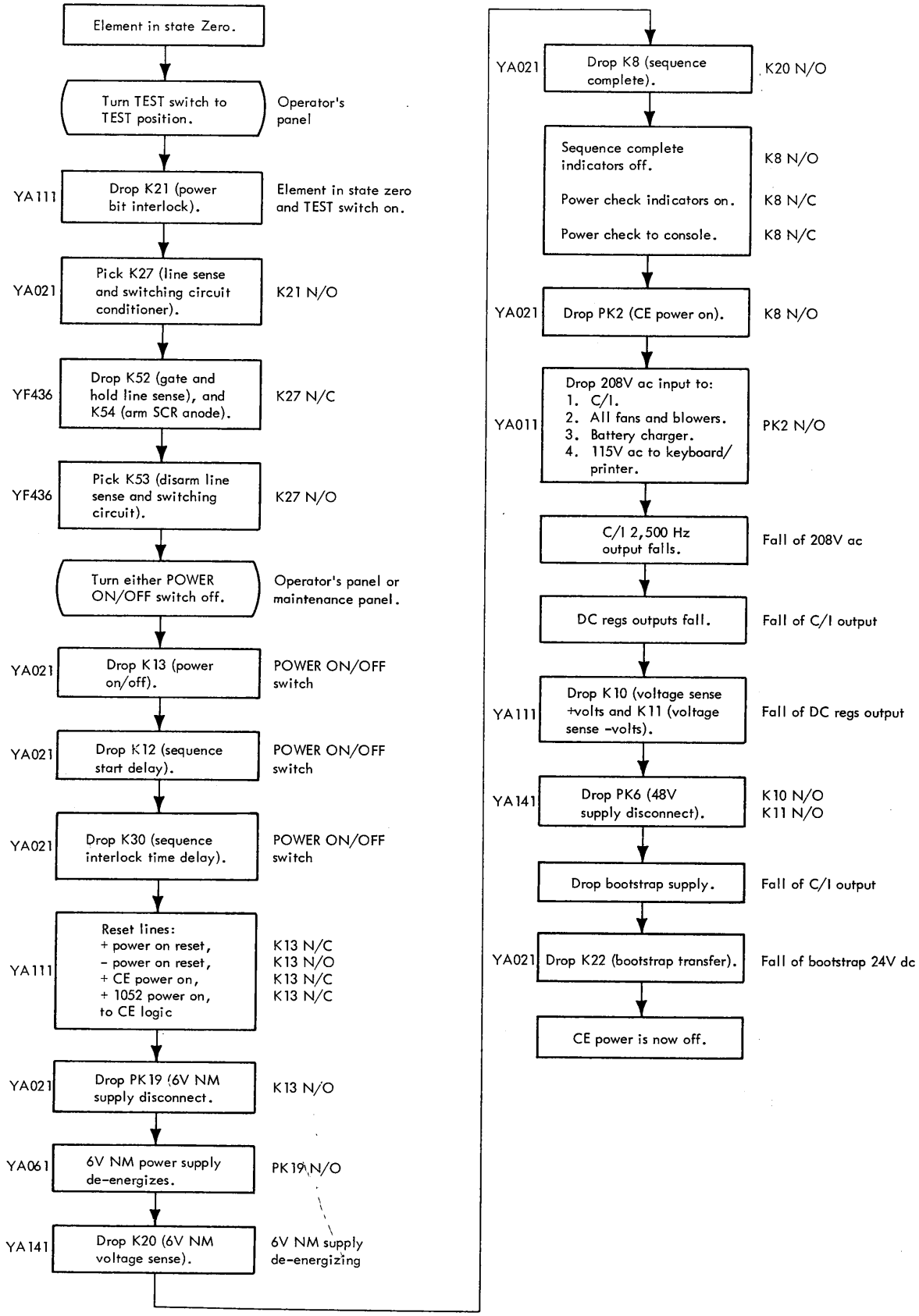


Figure 2-15. CE Normal Power-Off Sequence

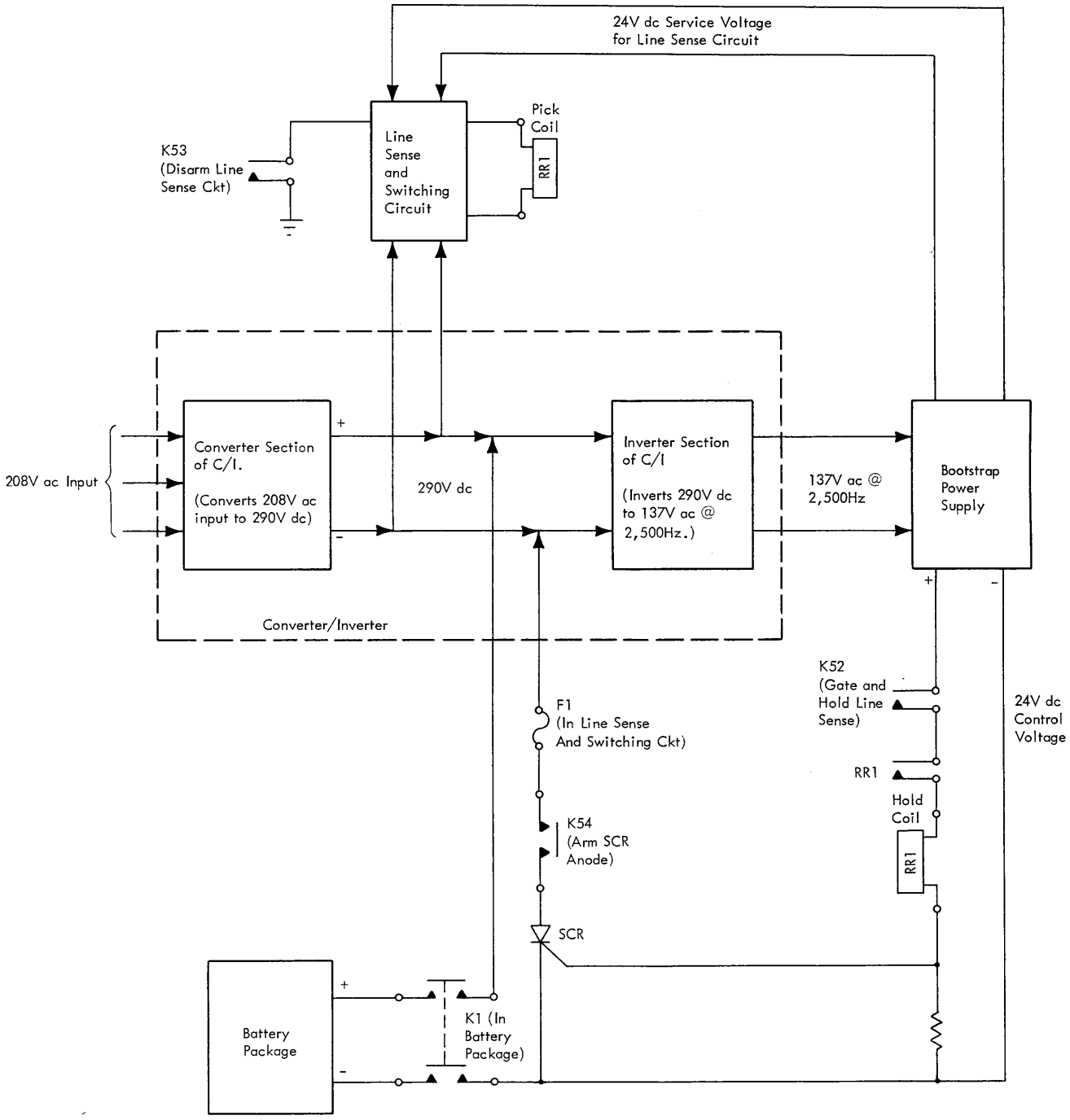


Figure 2-16. Battery Backup

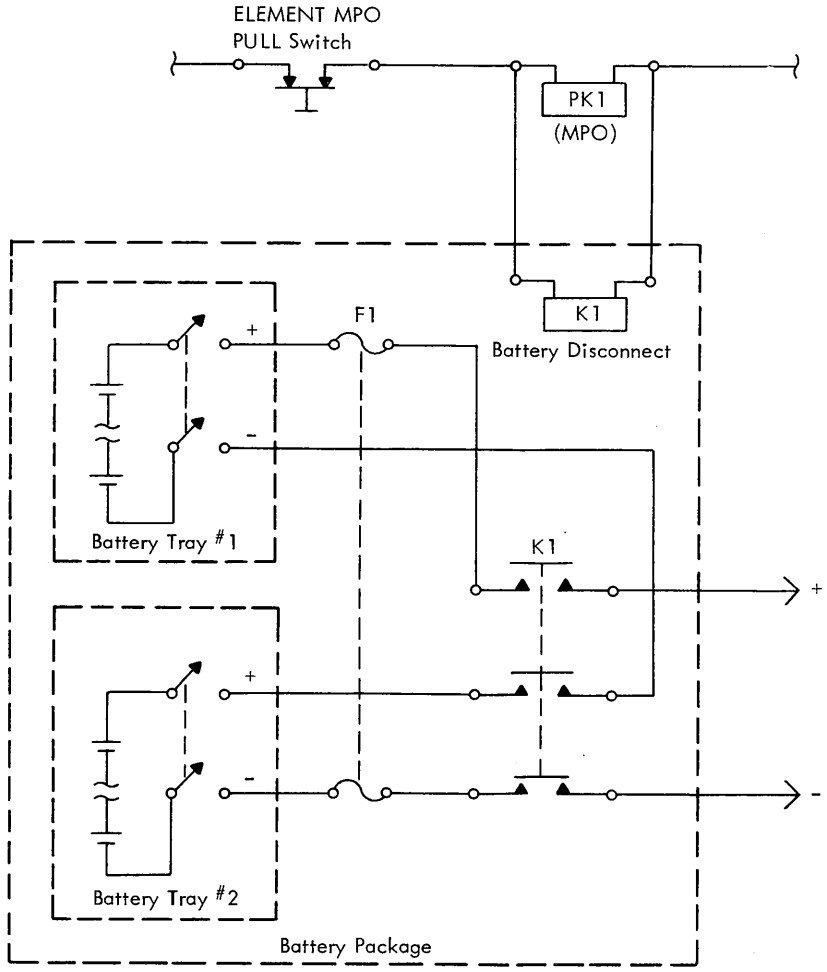


Figure 2-17. Battery Package

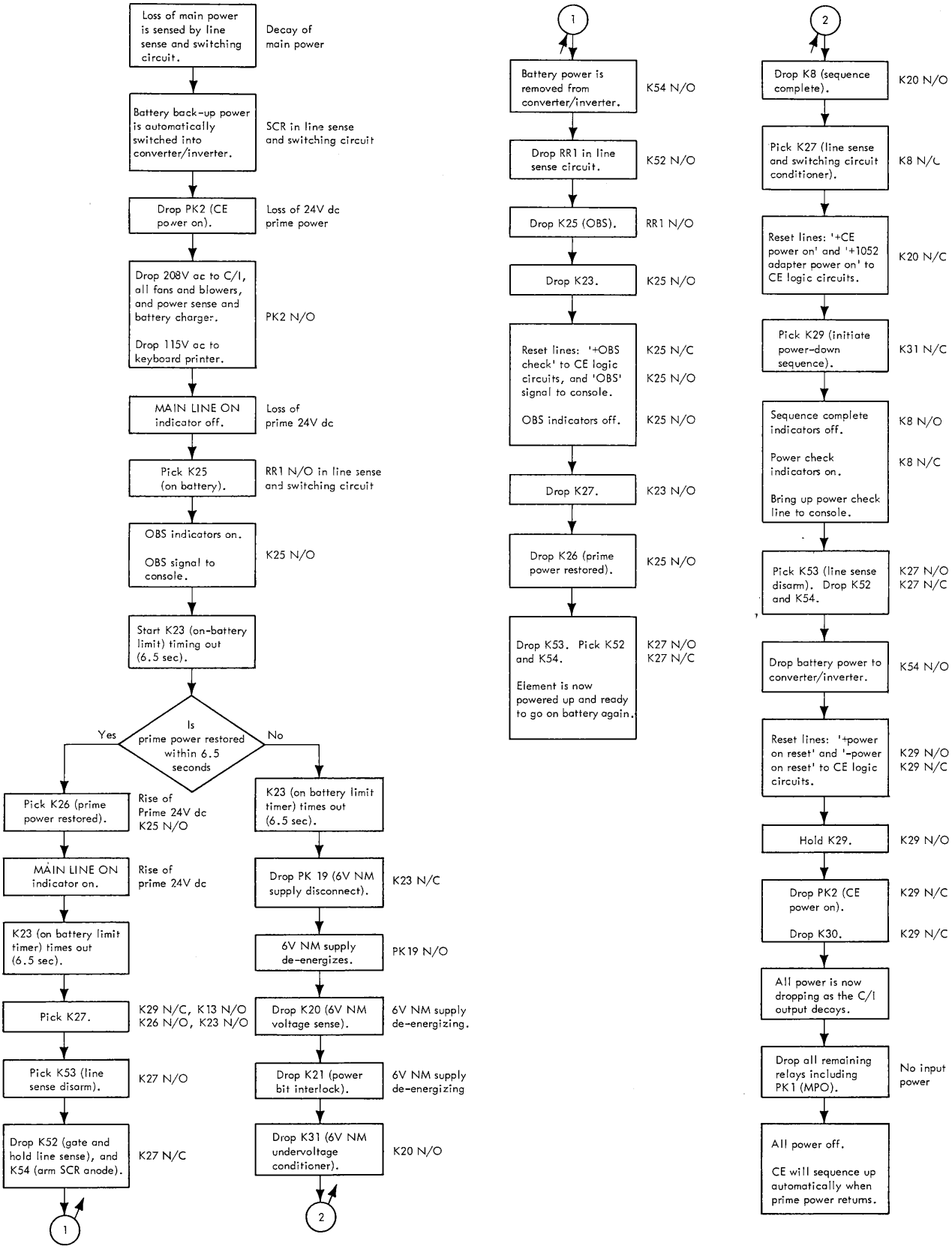

Loss of main power is sensed by line sense and switching circuit.
Decay of main power
Battery back-up power is automatically switched into converter/inverter.
SCR in line sense and switching circuit
Drop PK2 (CE power on).
Loss of 24V dc prime power
Drop 208V ac to C/I, all fans and blowers, and power sense and battery charger.
Drop 115V ac to keyboard printer.
PK2 N/O
MAIN LINE ON indicator off.
Loss of prime 24V dc
Pick K25 (on battery).
RR1 N/O in line sense and switching circuit
OBS indicators on.
OBS signal to console.
K25 N/O
Start K23 (on-battery limit) timing out (6.5 sec).
Is prime power restored within 6.5 seconds
Yes
No
Pick K26 (prime power restored).
Rise of Prime 24V dc K25 N/O
MAIN LINE ON indicator on.
Rise of prime 24V dc
K23 (on battery limit timer) times out (6.5 sec).
Pick K27.
K29 N/C, K13 N/O K26 N/O, K23 N/O
Pick K53 (line sense disarm).
K27 N/O
Drop K52 (gate and hold line sense), and K54 (arm SCR anode).
K27 N/C
1
K23 (on battery limit timer) times out (6.5 sec).
Drop PK 19 (6V NM supply disconnect).
K23 N/C
6V NM supply de-energizes.
PK19 N/O
Drop K20 (6V NM voltage sense).
6V NM supply de-energizing.
Drop K21 (power bit interlock).
6V NM supply de-energizing
Drop K31 (6V NM undervoltage conditioner).
K20 N/O
2
1
Battery power is removed from converter/inverter.
K54 N/O
Drop RR1 in line sense circuit.
K52 N/O
Drop K25 (OBS).
RR1 N/O
Drop K23.
K25 N/O
Reset lines: '+OBS check' to CE logic circuits, and 'OBS' signal to console.
K25 N/C
K25 N/O
OBS indicators off.
K25 N/O
Drop K27.
K23 N/O
Drop K26 (prime power restored).
K25 N/O
Drop K53. Pick K52 and K54.
Element is now powered up and ready to go on battery again.
K27 N/O
K27 N/C
2
Drop K8 (sequence complete).
K20 N/O
Pick K27 (line sense and switching circuit conditioner).
K8 N/C
Reset lines: '+CE power on' and '+1052 adapter power on' to CE logic circuits.
K20 N/C
Pick K29 (initiate power-down sequence).
K31 N/C
Sequence complete indicators off.
K8 N/O
Power check indicators on.
K8 N/C
Bring up power check line to console.
Pick K53 (line sense disarm). Drop K52 and K54.
K27 N/O
K27 N/C
Drop battery power to converter/inverter.
K54 N/O
Reset lines: '+power on reset' and '-power on reset' to CE logic circuits.
K29 N/O
K29 N/C
Hold K29.
K29 N/O
Drop PK2 (CE power on).
K29 N/C
Drop K30.
K29 N/C
All power is now dropping as the C/I output decays.
Drop all remaining relays including PK1 (MPO).
No input power
All power off.
CE will sequence up automatically when prime power returns.

Figure 2-18. Battery Backup Power

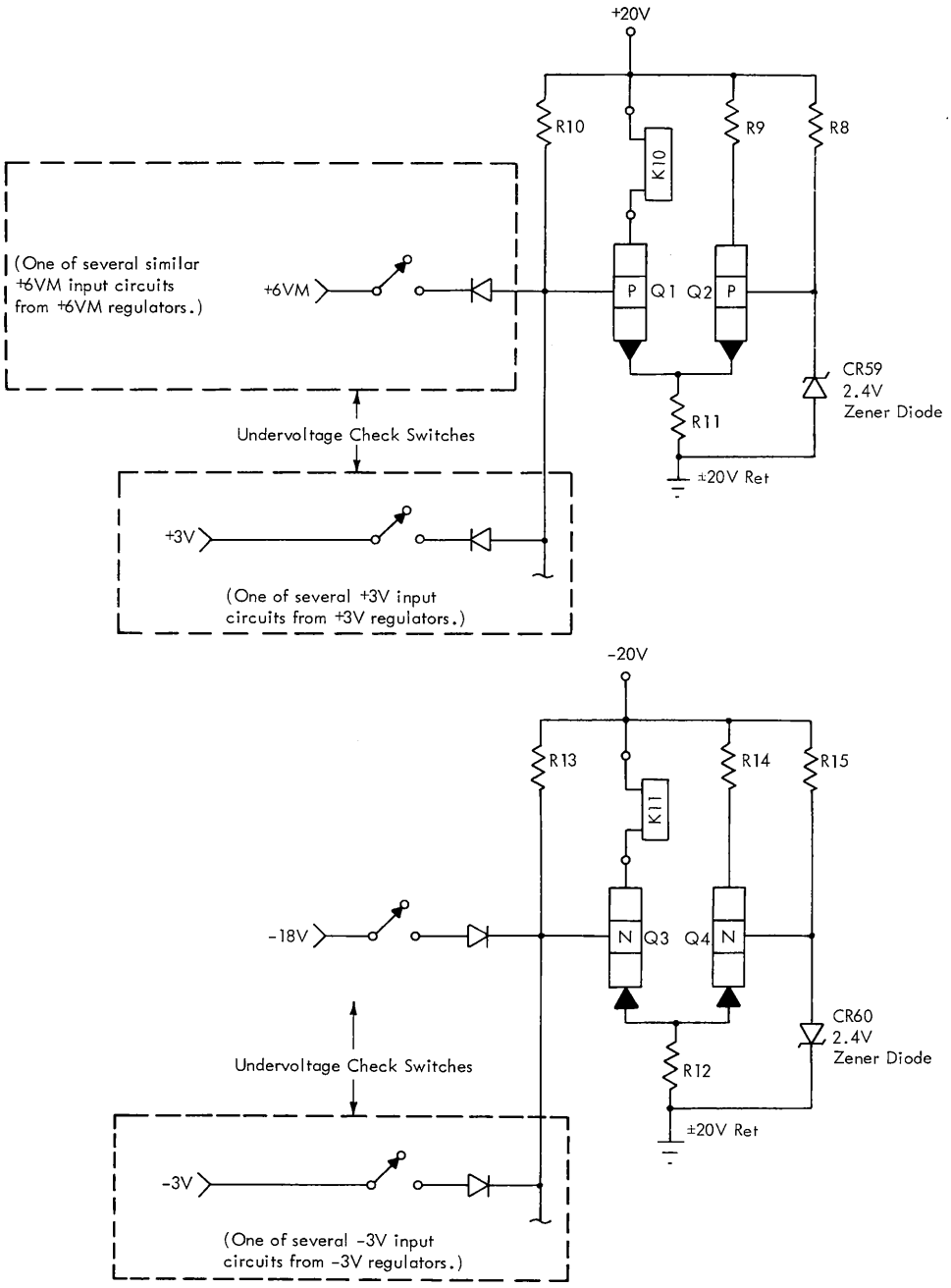


Figure 2-19. Undervoltage Sense Circuit

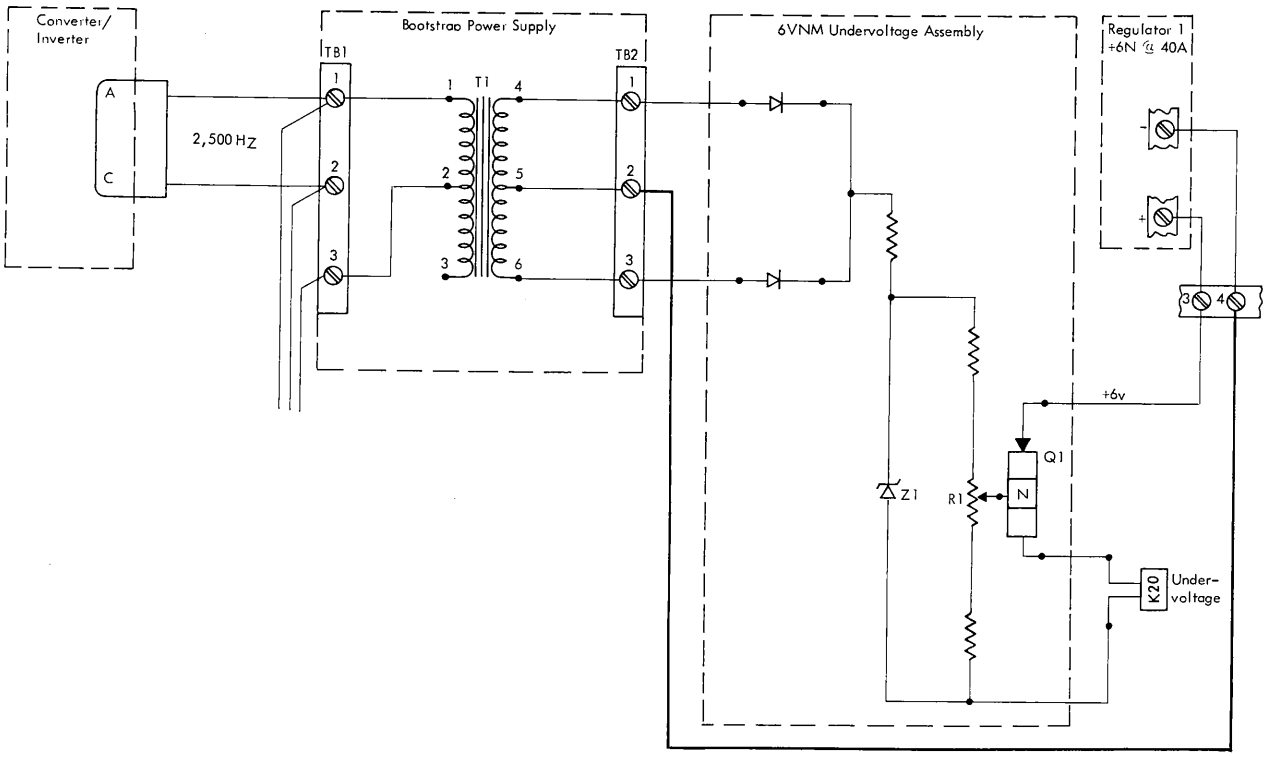


Figure 2-20. Undervoltage Protection Circuit for +6VNM Regulator

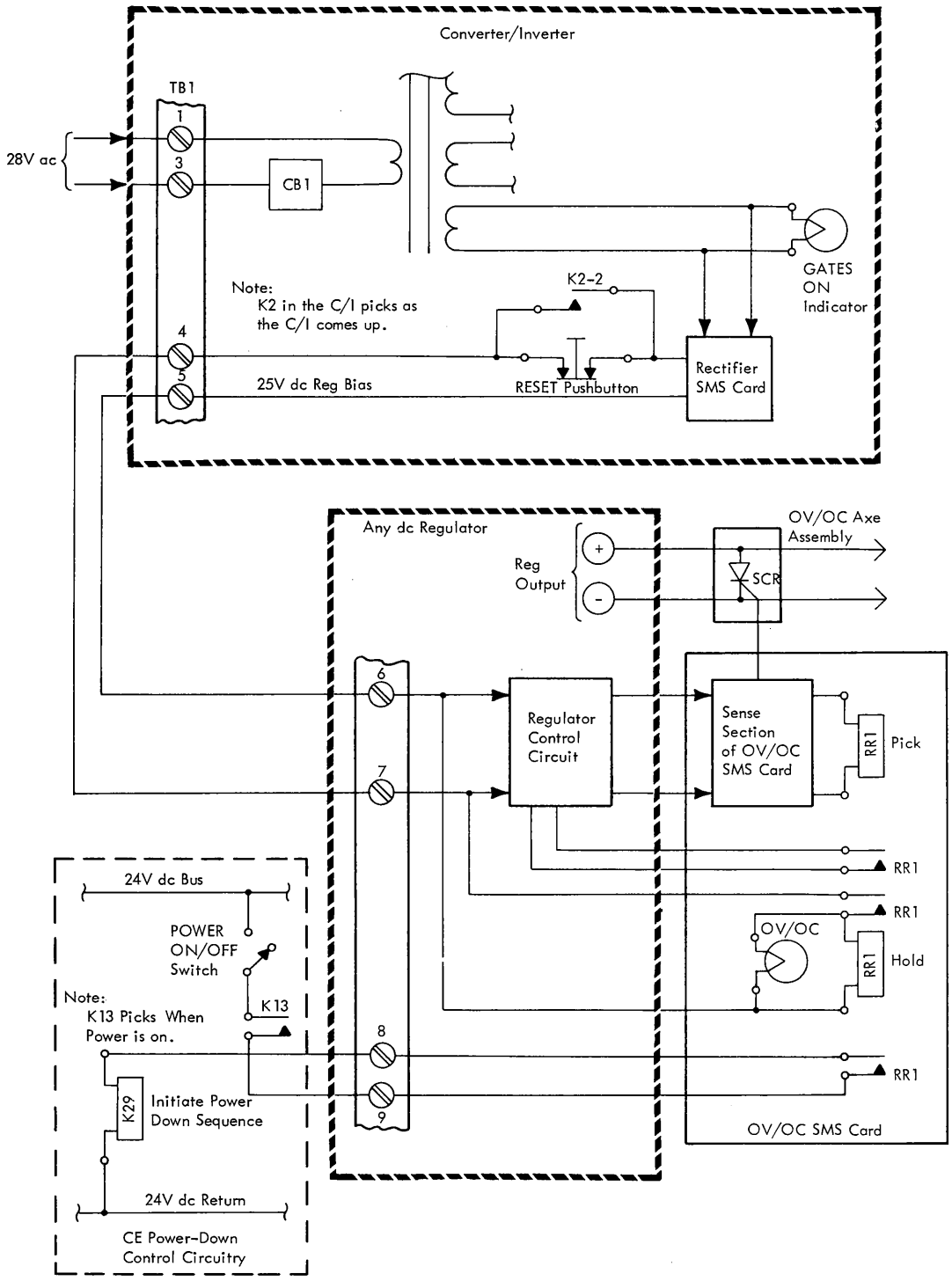
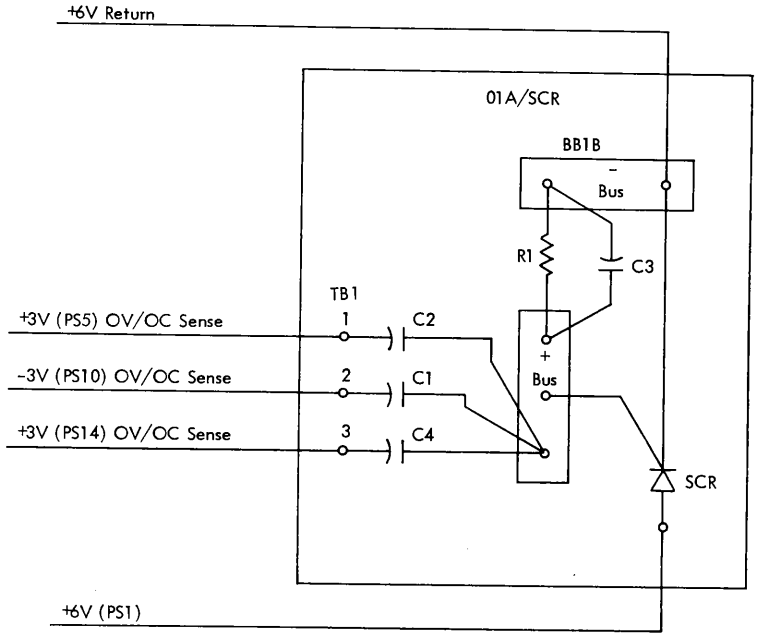
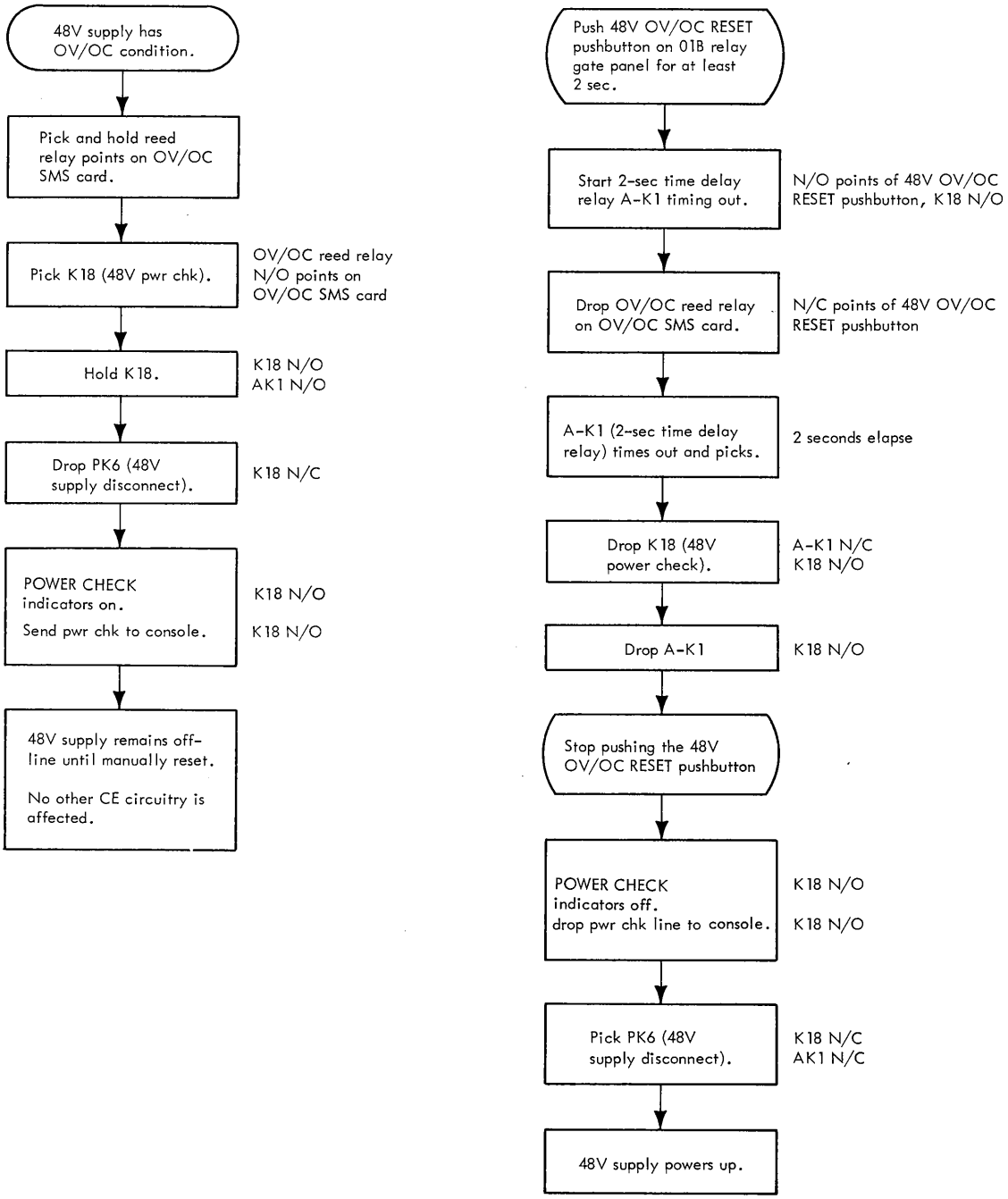


Figure 2-21. Regulator OV/OC Circuitry



● Figure 2-22. PS1 Axe Assembly


48V supply has OV/OC condition.
Pick and hold reed relay points on OV/OC SMS card.
Pick K18 (48V pwr chk).
OV/OC reed relay N/O points on OV/OC SMS card
Hold K18.
K18 N/O
AK1 N/O
Drop PK6 (48V supply disconnect).
K18 N/C
POWER CHECK indicators on.
Send pwr chk to console.
K18 N/O
K18 N/O
48V supply remains off-line until manually reset.
No other CE circuitry is affected.
Push 48V OV/OC RESET pushbutton on 01B relay gate panel for at least 2 sec.
Start 2-sec time delay relay A-K1 timing out.
N/O points of 48V OV/OC RESET pushbutton, K18 N/O
Drop OV/OC reed relay on OV/OC SMS card.
N/C points of 48V OV/OC RESET pushbutton
A-K1 (2-sec time delay relay) times out and picks.
2 seconds elapse
Drop K18 (48V power check).
A-K1 N/C
K18 N/O
Drop A-K1
K18 N/O
Stop pushing the 48V OV/OC RESET pushbutton
POWER CHECK indicators off.
drop pwr chk line to console.
K18 N/O
K18 N/O
Pick PK6 (48V supply disconnect).
K18 N/C
AK1 N/C
48V supply powers up.

● Figure 2-23. 48V Supply OV/OC

All IOCE components and controls associated with power distribution and control are described in this chapter. The protection and checking circuits (including EPO/MPO) for the IOCE, and the battery backup power is described in Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- A PDU frame has all main power assemblies.
- The IOCE control panel provides monitoring and control functions.

Figures 3-1 through 3-3 show the component locations within the IOCE. A power distribution unit (PDU) provides power distribution and control to the common logic unit (CLU), maintenance and channel (MACH) storage, and control panel sections of the IOCE. The PDU has one SLT modular frame with one logic gate (03J), in addition to the element's major power assemblies.

Components in the PDU include:

1. Circuit breakers, fuses, switches, contactors, and relays for power sequencing and distribution.
2. A +24V dc prime power supply.
3. A 75-amp converter/inverter (C/I).
4. Sixteen dc regulator supplies.
5. A battery backup power source that consists of a line sense and switching circuit (including a bootstrap assembly and charger).
6. Temperature thermals, overvoltage/overcurrent circuitry, and undervoltage protection circuitry.
7. A temperature controller for local storage.
8. A stepdown transformer to provide 115V ac convenience outlet power.
9. Switches to simulate out-of-tolerance check (OTC) and on-battery supply (OBS) conditions.

The IOCE control panel provides a variety of monitoring and control functions. These include:

1. An element master power off (MPO) switch for immediately removing all power from the IOCE.
2. A POWER ON/OFF switch used for normal power on/off sequences.
3. Indicators for visual determination of thermal, mainline power, on battery, open CB, and power check conditions.
4. A meter for monitoring the various dc supplies.
5. A MONITOR VOLTAGE SELECT switch that selects one of the nonmarginal voltages into the meter.
6. A MARGIN VOLTAGE SELECT switch that selects one of the marginal supply voltages into the meter.
7. Marginal voltage potentiometers and indicators associated with the various marginal supplies.
8. A TEST switch that is effective when the IOCE is in state zero.

Power Interlock Circuit

- Each IOCE is power-interlocked with the System Console (9020D), or with the Configuration Console (9020E).
- All main power is removed from the IOCE under EPO/MPO conditions.

Power interlocking is such that all main IOCE power can be removed under EPO/MPO conditions. Pulling the EPO switch on the system console (9020D systems), or on the Configuration Console (9020E system) removes power from all elements on that system; pulling the IOCE MPO switch removes power from only that IOCE.

Figure 3-4 shows the IOCE power interlock circuitry. Under normal or EPO/MPO power-off conditions, a prime +24V dc service voltage is still available between all elements and the console. With the EPO switch closed at the console, the IOCE (or any element) can pick and hold the EPO contactor. In the IOCE, this circuit is from the prime +24V dc source, through the K1 N/C points, to the console, through the EPO switches and EPO relay coil, and to the common 24V dc return path.

The N/O points in the console provide a pick circuit for the MPO contactor in the IOCE. The MPO circuit is through the K1 N/C points, through the MPO switch and the K43 contactor, to the console, through the EPO relay N/O contacts, and to the common 24V dc return path.

When K43 side switches A and B are closed in the IOCE, +24V dc is applied to the power sequence and control circuitry and the MAINLINE ON indicator. Operation of the power sequence and control circuitry also depends on the setting of POWER ON/OFF.

The main points of K43 gate 3-phase, 208V ac power into the main power area of the PDU. Operation within the main power area also depends on the setting of the POWER ON/OFF switch as described in detail later.

An additional contactor (K1) is connected in parallel with K43 (Figure 3-4). This contactor is in the battery package and it prevents high dc voltages from leaving this area under EPO/MPO conditions.

AC Distribution

- 208V, 3-phase, 60-Hz input power.
- Under normal power-off conditions, ac power is available to:
  1. The convenience outlets.
  2. The C/I blowers.
  3. The 28V as C/I bias.
  4. The +24V dc prime power.
- Under EPO/MPO conditions, only the +24V dc prime power exists.

The ac input includes 3-phase, 208V, 60-Hz power that is routed directly from the customer's ac service outlet to a filter network (Figure 3-5). The capacitors in this network eliminate any unwanted input electrical noise which could have adverse effects on the IOCE circuitry (especially in the more critical areas of MACH and local storage). Each ac feed capacitor in the filter network has a 1-megohm resistor that is connected to ground. These resistors bleed off any charge that remains on the capacitors when the ac service is disconnected.

Initial turn-on of mainline circuit breaker CB1 applies 208V ac, single-phase power via fuses F1 and F2 to the +24V dc prime power supply which provides power via N/C contacts of K1 to the +24V dc bus.

The +24V is routed first to the system emergency power-off (EPO) circuit in the system or configuration console (Figure 3-4). If the EPO switch is closed, the EPO relay (in the console) picks, providing a return for the element's master power off (MPO) contactor K43. If the element's MPO switch is closed, +24V dc is applied to the other leg of MPO relay K43, causing it to pick.

From the contacts of K43, 208V ac, single-phase power is routed via circuit breaker CB12 to a stepdown transformer which provides 115V ac to the convenience outlets in the PDU, CLU, and MACH storage.

Single-phase, 208V ac power is also applied via circuit breaker CB9 to transformer T1. The secondary of T1 initially supplies 28V ac via relay K1 N/C contacts to the converter/inverter. The output of CB9 also supplies 208V ac, single-phase power to blowers in the converter/inverter.

With the K43 contacts closed, +24V dc is now applied to the sequence and control relays through K43 SSWA and SSWB.

Under normal power-off conditions, power is available to the following IOCE circuitry:

1. 115V ac convenience outlets.
2. 208V ac to the C/I blowers.
3. 28V ac to the C/I bias circuitry.
4. +24V dc to the power sequence and control circuitry.
5. +24V dc to the EPO/MPO circuitry.

Note: Under EPO/MPO conditions, power is still available at the +24V dc prime power transformer and +24V dc is active in the power interlock cable to the console. This 24V is needed to return power to the system elements when the EPO/MPO condition is removed. All power can be removed from the IOCE only by opening CB1 or the main customer service outlet.

Before further distribution of 208V ac can occur, relays K44, K50, and K51 must be picked (Figure 3-5). The picking of these relays occurs only after the operator's and PDU panel POWER ON/OFF switches are on and the sequence start time delay relay K45 has been picked. From the contacts of K43, 208V ac (Figure 3-5) is applied to K50 and K44 (ac on). K50 is also picked at this time and single-phase, 208V power is applied to all remaining blowers within the IOCE via CBs 3–8 and 11.

K44 controls the 3-phase, 208V ac input to the converter/inverter and the single-phase, 208V ac input to the temperature controller, line sense, and switching circuit, and to the primary of transformer T2. The secondary of T2 (12.6V ac) is routed to the interval timer.

When the C/I is on, its 2500 Hz square-wave output is routed to the 16 standard dc voltage regulators and to the bootstrap power supply. This bootstrap power supply provides the following outputs (Figure 3-5):

1. 28V ac bias for the C/I circuitry.
2. Reference voltages to the undervoltage sense system circuitry.
3. +24V dc to the line sense and switching circuit.
4. +24V dc via N/O contacts of K15 or K27 to bootstrap power relay K1.
5. +24V dc for the power sequence and control circuitry.

When K1 is picked, the bootstrap power supply provides the 28V ac input the C/I and +24V dc to the +24V dc bus through N/O contacts of K1.

DC Distribution

- 16 dc voltage regulator supplies.
- 2500-Hz primary input to all regulators.

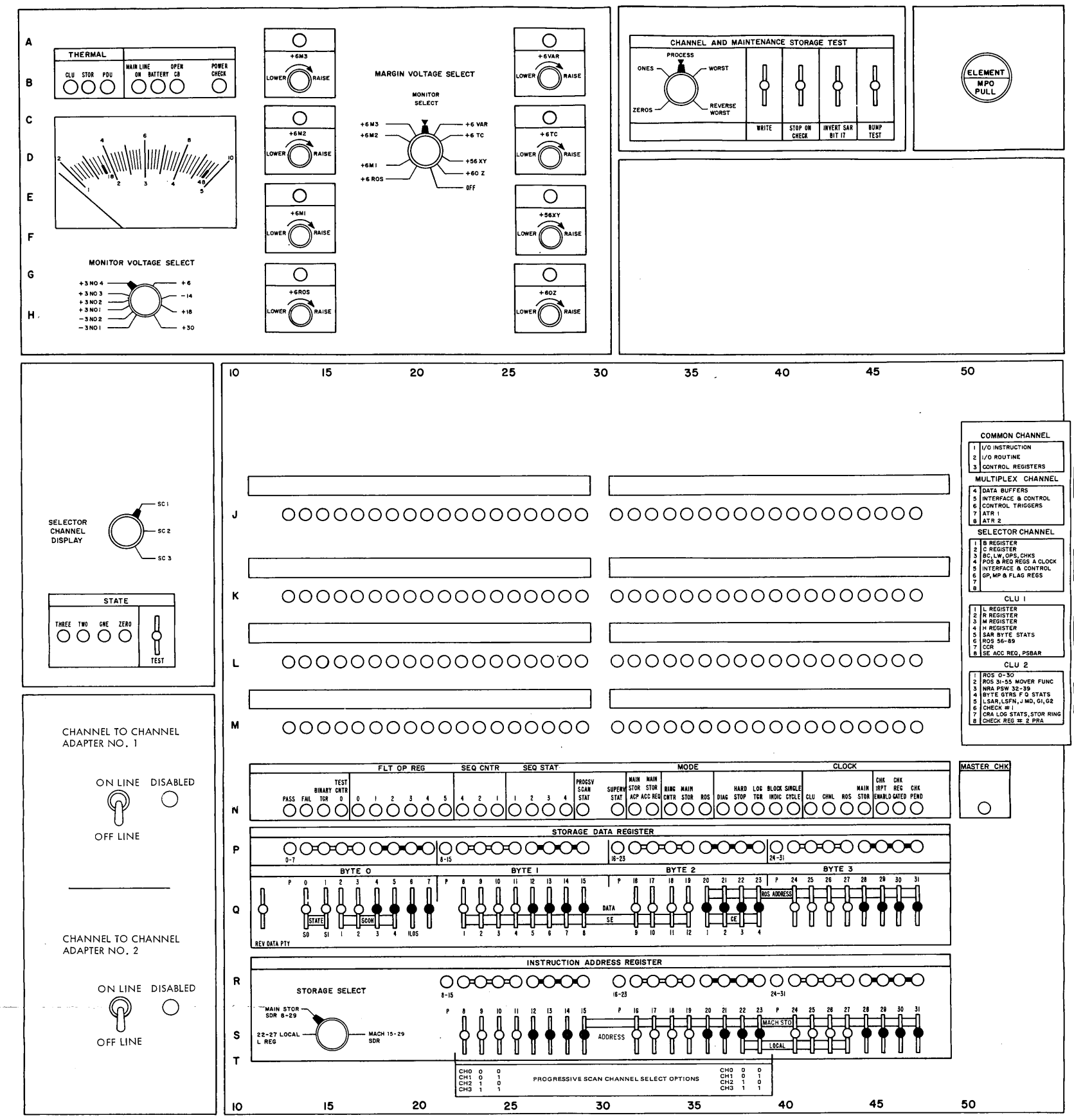


Figure 3-1. IOCE Control Panel

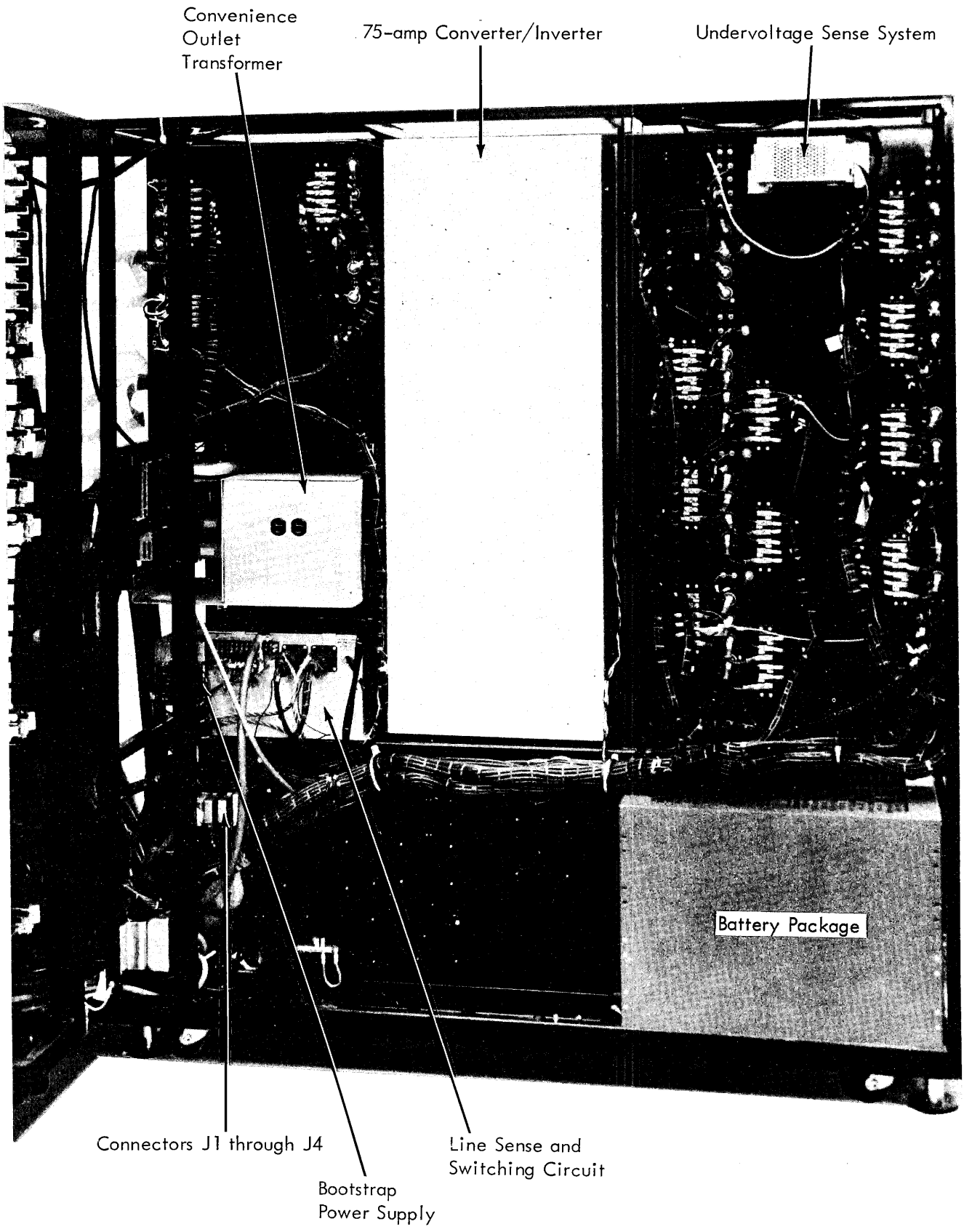


Figure 3-2. IOCE Power Distribution Unit (Front View)

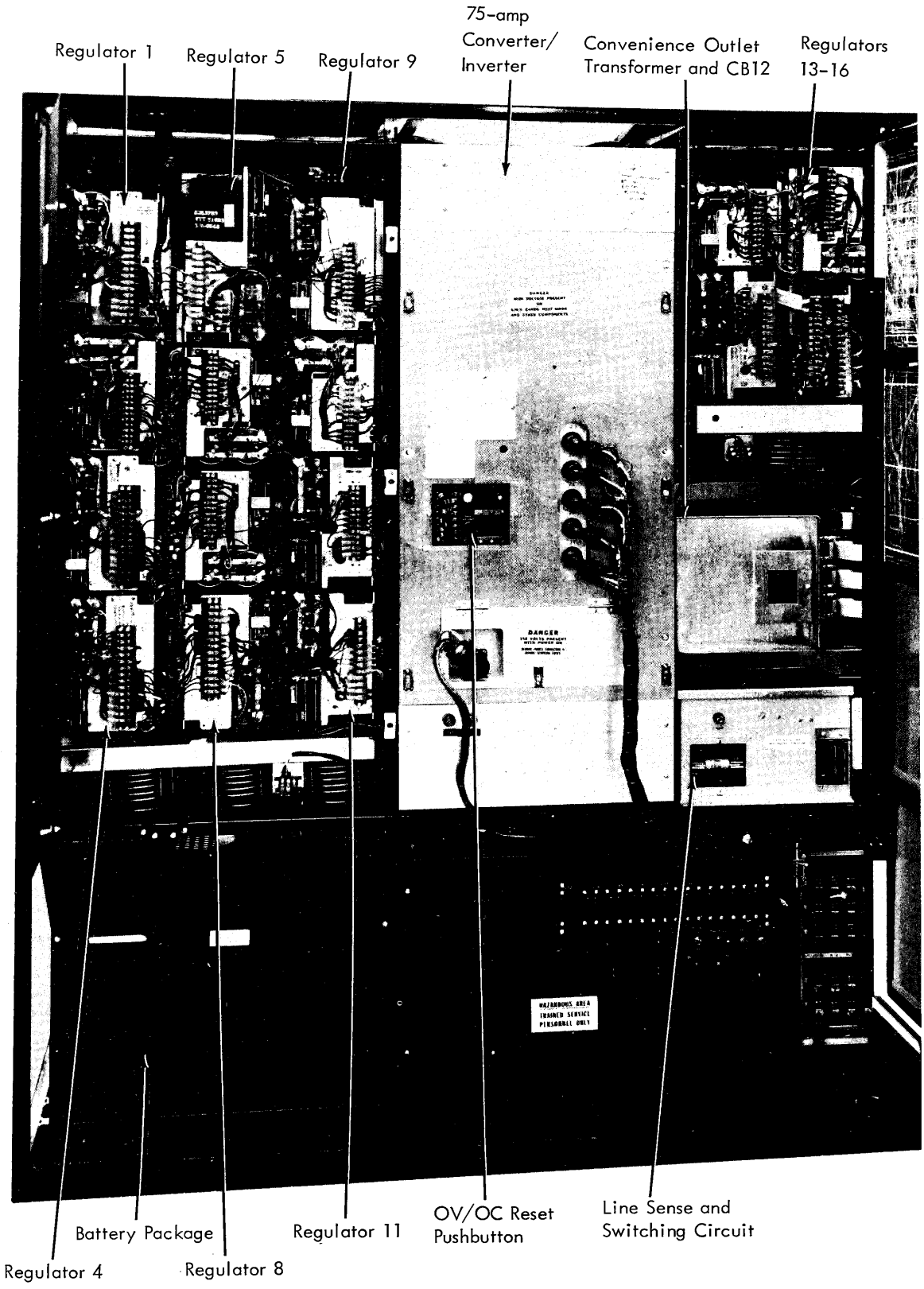


Figure 3-3. IOCE Power Distribution Unit (Rear View)

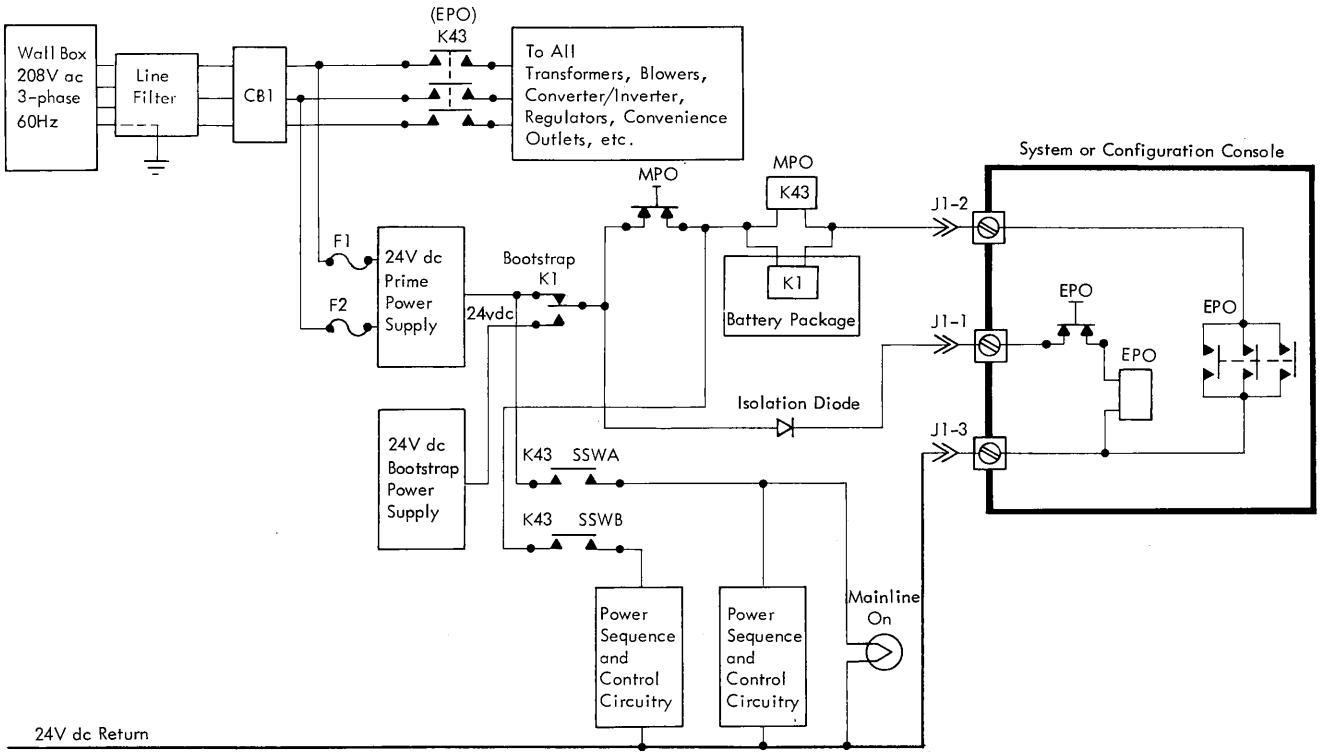


Figure 3-4. IOCE Power Interlock Circuitry

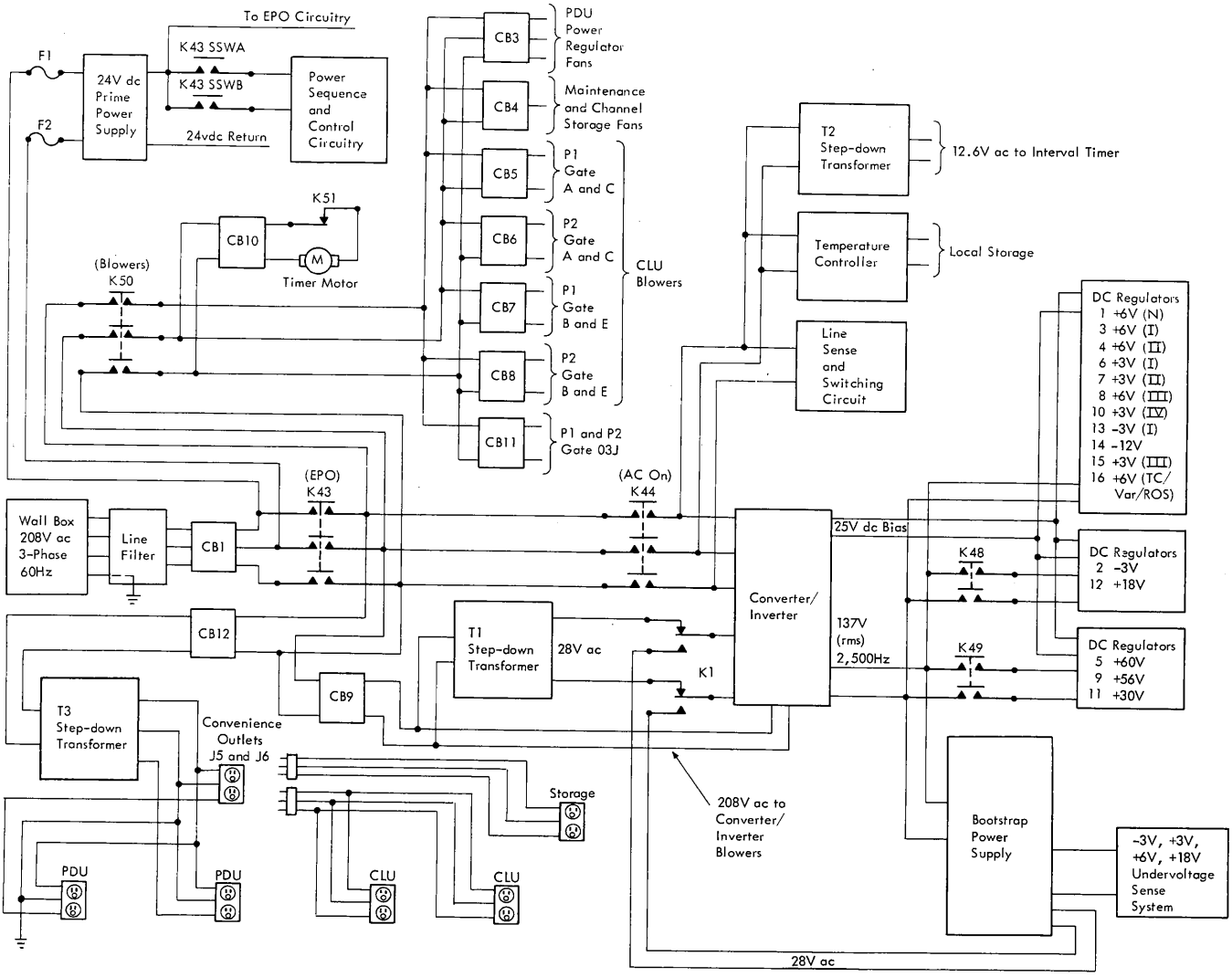


Figure 3-5. IOCE AC Distribution

- All regulator supplies are relay-sensed.
- Standard dc bus distribution.

All dc voltages, except the +24V and +25V power sequence and control voltages, are obtained from regulators.

The IOCE has 16 regulators to satisfy the power requirements of the element (Figure 3-6). In some cases (+6V, +3V, and -3V), more than one regulator supplies the required amount of power. Input power to these regulators is from the C/I as a 2500 Hz, 137V (rms) square wave.

Application of the input is such that the regulator voltages come up in three groups: the logic voltages, the middle voltages, and the high voltages. The last two groups are under control of contactors K48 and K49; a detailed description of their operation is under "Power-On Sequence" below.

Each regulator is monitored by a sense relay which controls the proper power on and off sequencing in the IOCE.

Table 3-1 lists the various regulators with their voltage and current ratings, sense relays, and gates to which power is supplied.

Power-On Sequence

- DC voltages sequence up in three groups:
  1. Logic voltages.
  2. +18V and -3V.
  3. High voltages (+56V and +60V).

Refer to Figures 3-7 and 3-8. Before the power-on sequence can begin in the IOCE, circuit breaker CB1 must be closed and system EPO contactor K37 and element MPO contactor K43 must be energized. Before the power-on sequence begins, the following conditions exist:

1. The MAINLINE ON indicator is on.
2. The POWER CHECK indicator is on through N/C contacts of K4 to indicate that a normal power-off situation prevails.
3. If all thermal elements are in the N/C position, thermal relays K7–K12 are picked via K6 N/C contacts. After the thermal relay contacts transfer, each relay is held picked through its N/O contacts. The N/C contacts of K7–K12 turn on the THERMAL indicators.
4. If CB1 and CB3 through CB11 are closed, relay K16 (CB trip) remains de-energized. Relay K17 (power fault interlock) is picked if the points of C/I CB2-1 are closed and relay K14 (overvoltage/overcurrent hold) is not picked.

With these initial requirements satisfied, the power-on sequence begins by setting the POWER ON/OFF switches to ON which completes the circuit that picks relay K2 (power on/off). The C/I auxiliary K1-5 N/C points are also in the power-on circuit to prevent power from coming up if a C/I relay driver malfunction occurs.

Table 3-1. IOCE Regulator Ratings, Distribution, and Sensing

Regulator	Nominal Voltage	Ampere Rating	Logic Gate	Terminal Board	Sense Relay
1	+6 (Non-marginal)	40.0	CLU-A CLU-C Storage	TB2-6 CU08D-8 TB1-8	K32
2	-3 (2)	40.0	CLU-C CLU-B Storage	TB2-10, CU08D-10 TB1-10, TB2-10 TB1-12	K27
3	+6 (1)	40.0	CLU-A CLU-C	TB1-8, TB2-8 TB2-12	K28
4	+6 (2)	40.0	CLU-B PDU-03J	TB1-12, TB2-12 TB1-12, TB2-12	K29
5	+60 (Z)	8.0	Storage	TB1-4	K37
6	+3 (1)	40.0	CLU-A Storage	TB1-12 TB1-10	K22
7	+3 (2)	40.0	CLU-A CLU-B	TB2-12 TB1-8	K23
8	+6 (3)	40.0	CLU-E	TB1-12, TB2-12	K30
9	+56 (XY)	4.0	Storage	TB1-2	K36
10	+3 (4)	40.0	CLU-B PDU-03J	TB2-8 TB1-8, TB2-8	K26
11	+30	5.0	CLU-A	TB2-1	K35
12	+18	11.0	CLU-A Storage	TB2-3 TB1-6	K34
13	-3 (1)	20.0	CLU-A CLU-B	TB1-10, TB2-10 TB1-10, TB2-10	K25
14	-12 ±6	4.0	CLU-C	CU08D-6	K33
15	+3 (3)	40.0	CLU-C CLU-E	TB2-8, CU08D-4 TB1-8, TB2-8	K24
16	+6.3 (ROS) +6 (TC) +6 (Vor)	2.5 1.5 0.5	CLU-C CLU-A CLU-A	CU18D-2 TB2-5 TB2-4	K31

The N/O contacts of K2 provide a return for thermal reset relay K6 and relay K45 (sequence start delay), causing both relays to pick. Relay K6 holds through its N/O points until a manual thermal reset is begun, or either an EPO or element MPO condition occurs.

Relay K45 is adjustable from 5 to 30 seconds and is set to allow staggering of the 9020 system power-on sequence. This delay must be a minimum of 5 seconds to allow the C/I bias voltage time to react before the main power is

applied. When relay K45 times out, its N/O contacts allow time delay relay K46 (sequence interlock) to start timing. This time delay for relay K46 is adjusted to a value greater than the total time necessary to sequence power up in this element. (A reasonable value is +9 to 12 seconds.) Under normal conditions, therefore, the K46 points close after all power has sequenced up in the IOCE.

Relay K45 also picks contactor K44 (ac on) and heavy-duty relay K51 (ac on) in parallel. When contactor K44 is picked, 3-phase, 208V ac power (Figure 3-5) is applied to the C/I, and single-phase, 208V ac power is routed to the temperature controller, line sense and switching circuit, and to transformer T2. Heavy-duty relay K51 picks contactor K50 (blowers) which supplies 208V, single-phase power to blowers and fans in the CLU, PDU, and MACH storage.

The C/I 2500 Hz output is routed directly to the bootstrap power supply and to dc regulators 1, 3, 4, 6, 7, 8, 10, and 13–16. When the regulator outputs are sensed, relays K22–K26 and K28–K33 are picked.

Relay K5 (logic voltage sense) is picked via the transferred contacts of K22 through K26 and K28 through K33. The pick of K5, therefore, indicates that all low voltages of the first regulator group have sequenced up. The N/O contacts of K5 complete the return for heavy-duty relay K48 (+18V and +30V P/S on), causing this relay to pick. Relay K48 controls the 2500 Hz input to regulator 2 (-3V) and regulator 12 (+18V). Applying power to these two regulators initiates power for the middle group of voltages. Regulators 2 and 12 pick sense relays K27 and K35, respectively. N/O contacts of K27 provide a return for relay K1 (bootstrap power), causing this relay to pick. With K1 picked, the 24 volts to the 24V dc bus and the 28V ac input to the C/I is applied from the bootstrap power supply.

N/O contacts of K27 and K34 complete the return for relay K49 (high voltage on), allowing this relay to pick. Relay K49 controls the 2500 Hz input to regulator 11 (+30V), regulator 9 (+56V), and regulator 5 (+60V). Regulators 11, 9, and 5 pick sense relays K35, K36, and K37, respectively. N/O contacts of K35, K36, and K37 control the picking of relay K4 (sequence complete). When K4 is picked, the POWER SEQUENCE COMPLETE indicator is turned on, and the POWER CHECK indicator is turned off.

Relay K46 (sequence interlock time delay) should now pick. When the contacts of K46 transfer, relay K3 (sequence interlock) is picked and a power-on reset signal is sent to the logic circuitry.

The K3 N/C points test the sequencing circuitry by opening the pick circuits of the K44 and K51 (ac on) relays, and the K48 and K49 middle and high voltage relays. If power has been sequenced up, hold circuits have already been established by either a K34–K27 (middle voltage) combination or by K4 (sequence complete).

After power comes up, the IOCE is in operational state zero. If the TEST switch is off, relay K42 (power bit interlock) picks through logic circuitry and holds through its K42 points. The K42 points functionally disable the POWER ON/OFF switches by providing a hold circuit for K44. If the executive control (EXC) program configures the IOCE out of state zero, power cannot be removed (except under EPO/MPO conditions) without requesting a reconfiguration back into state zero. With the IOCE in state zero and the TEST switch on, K42 drops and the POWER ON/OFF switches are effective.

Normal Power-Off Sequence

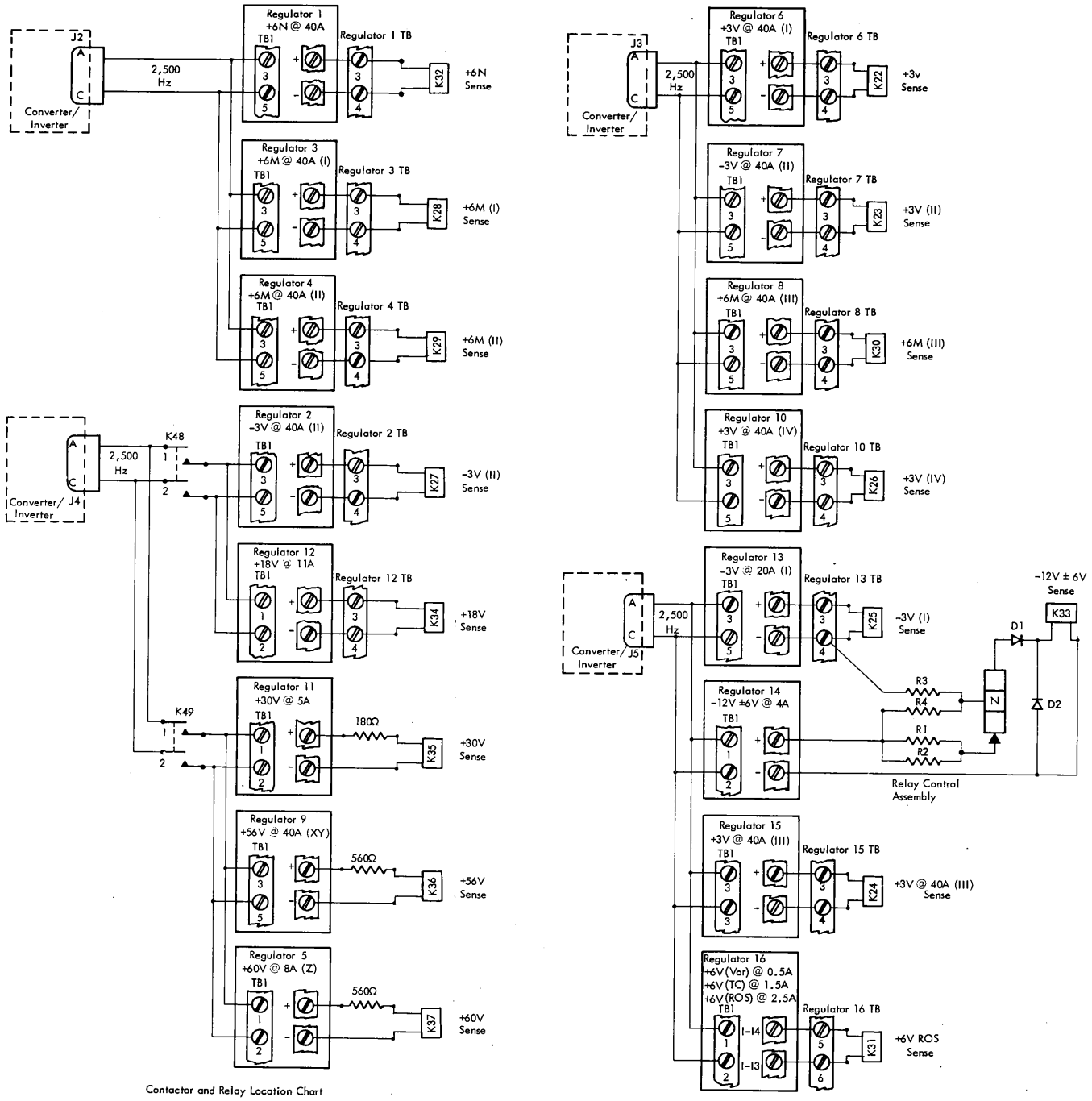
- DC voltages sequence off in three groups.
- Blowers remain on for an additional 3 to 4.5 minutes.
- Battery backup is prevented from switching into the IOCE.

Refer to Figures 3-7 and 3-9. To initiate a normal power-off sequence, the IOCE must be in state zero (state zero indicator on) and the TEST switch on the operator's control panel must be set to the on position. These two conditions cause relay K42 (power bit interlock) to remain de-energized. The N/O contacts of relay K42 interrupt the hold path for relay K2 (power on/off) which bypasses the POWER ON/OFF switches.

When either the operator's control or PDU panel POWER ON/OFF switches are set to OFF, relay K2 is dropped. The transfer of K2 contacts to their N/O position interrupts the return for relay K45 (sequence start delay), causing relay K46 (sequence interlock time delay) to drop. When the contacts of relay K46 transfer, relay K3 (sequence interlock) is dropped and the initial time delay circuitry is ready for the next power-on sequence.

The N/O K2 points also open the hold circuit for K49 (high voltage) so that the high voltages can be the first ones removed from the circuitry. Dropping relay K49 removes input power from regulator 11 (+30V), regulator 9 (+56V XY), and regulator 5 (+60V Z). When these regulator outputs are removed, relays K35–K37 are dropped, respectively. The N/O contacts of K35–K37 cause relay K4 (sequence complete) to drop. The POWER CHECK indicator is turned on (K4 N/C), the POWER SEQUENCE COMPLETE indicator is turned off (K4 N/O), and the K4 N/C points decondition the line sense and switching circuitry to prevent battery backup power from taking control.

Also, the N/O contacts of K35, K36, and K37 cause relay K48 (+18V and -3V P/S on) to be dropped. Note that



Contactor and Relay Location Chart

Reference Description	Logic Page Location	Reference Description	Logic Page Location *	Reference Description	Logic Page Location	Reference Description	Logic Page Location	Reference Description	Logic Page Location
K1	YE311	K12	YE511	K27	YE711				
K2	YE411	K13	YE411	K28	YE711	K42	YE411	K52	YE813
K3	YE411	K14	YE411	K29	YE711	K43	YE411	K53	YE813
K4	YE411	K15	YE511	K30	YE721	K44	YE411		
K5	YE411	K16	YE511	K31	YE751	K45	YE411		
K6	YE511	K17	YE411	K32	YE711	K46	YE411		
K7	YE511	K22	YE721	K33	YE421	K47	YE411		
K8	YE511	K23	YE721	K34	YE731	K48	YE411		
K9	YE511	K24	YE741	K35	YE731	K49	YE411		
K10	YE511	K25	YE741	K36	YE731	K50	YE411		
K11	YE511	K26	YE721	K37	YE731	K51	YE411		

● Figure 3-6. IOCE DC Voltage Regulator Supplies and Controls

these three points in parallel hold K48 until all three high-voltage supplies have decayed. Dropping relay K48 removes input power from regulator 2 (-3V No. 2) and regulator 12 (+18V).

Removing these two middle voltage regulator outputs drops relays K27 and K34, respectively. The N/O contacts of K27 cause relay K1 (bootstrap power) to drop. With K1 dropped, the +24V dc to the dc bus is supplied from the +24V prime power, and the 28V ac to the C/I is supplied from transformer T1.

The N/O contacts of relays K27 and K34 cause relays K44 and K51 (ac on) to be dropped. Note that these two points in parallel hold K44 until both middle voltages have decayed. When relay K44 is dropped, 3-phase, 208V ac power (Figure 3-5) is removed from the C/I, and single-phase, 208V ac power is removed from the temperature controller, line sense and switching circuit, and transformer T2. De-energizing the C/I turns off the remaining standard voltage regulators (logic voltage group) and the bootstrap power supply. Removing the outputs from regulators 1, 3, 4, 6, 7, 8, 10, 13–16 causes the associated sense relays K22–K26 and K28–K33 to drop. When the contacts of these sense relays transfer, relay K5 (logic voltage sense) drops.

All dc voltages have now been removed from the IOCE, except the +24V dc to the power sequence and control circuitry and power interlock (EPO/MPO) circuitry. Existing ac power includes ac input power, power to the convenience outlets, 28V ac to the C/I, and 208V power to the blowers and fans.

All main blowers continue to operate for 3 to 4.5 minutes after dc power is sequenced off. Blower contactor K50 holds through its points and the N/C timer points. This blower delay begins when K44 and K51 drop. When the K51 N/C points are closed, a circuit to the timer motor is complete (Figure 3-5). After 3 to 4.5 minutes, the N/C points open momentarily. K50 drops, and the blower motors stop. The C/I blower is not affected by this circuitry and continues to operate when the other blowers have stopped.

Battery Backup Power Control

- Uninterrupted battery backup power for 6.5 ±0.5 seconds.
- Loss of primary power is sensed as a decay of C/I output.
- Battery backup power is not applied under EPO/MPO conditions.

The IOCE has a battery backup power source that permits uninterrupted power for 6.5 ±0.5 seconds, following the loss of the 208V ac primary input power.

Loss of primary input power is sensed as a decay in the C/I output. When this output drops below a preset limit, an already conditioned silicon-controlled rectifier (SCR) fires and feeds battery power into the C/I dc output bus. This high-speed SCR switching occurs without interruption to the 2500-Hz C/I output.

Note: The battery package output is not applied to the C/I during emergency power-off conditions.

Figure 3-10 shows the IOCE battery backup power operation when either prime power is restored before 6.5 seconds or when power sequences off because prime power was not restored within the 6.5 second on-battery limit period.

Battery Backup with Prime Power Restored

- Battery power is removed automatically and replaced with prime power after 6.5 seconds.

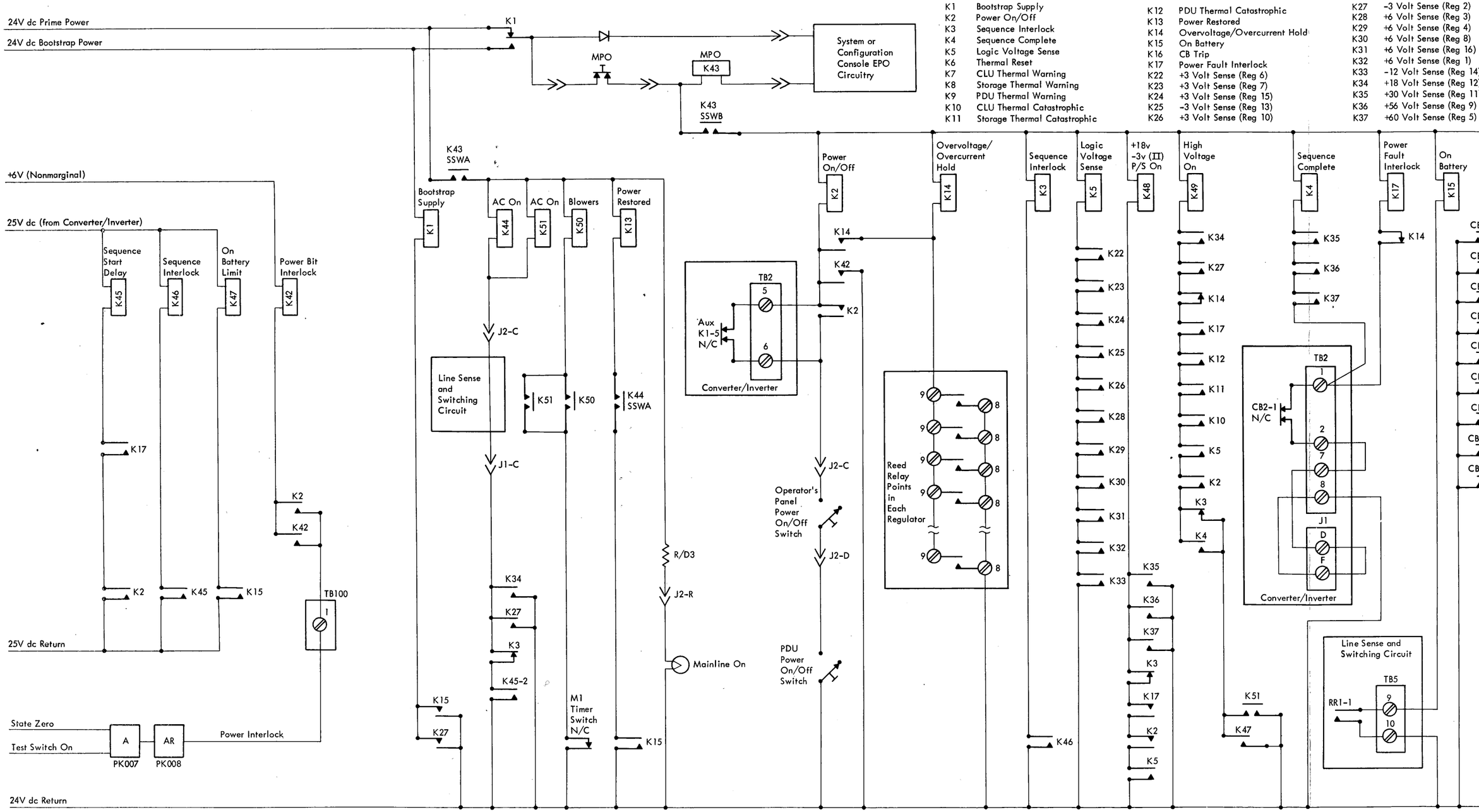
When the SCR switches battery power into the IOCE, reed relay 1 (RR1) is picked in the line sense and switching circuit and provides a pick circuit for K15 (on battery). The points of K15 turn on a BATTERY indicator on the IOCE control panel and the system or configuration console operator's panel. An 'on-battery' signal is also sent to the IOCE logic circuit. Switching to battery power also starts the 5.5-second on-battery limit time delay relay (K47).

When prime power was lost, K44 and K51 (ac on) dropped, K50 (blowers) dropped, the MAINLINE ON indicator was turned off (Figures 3-7 and 3-9). These items were all fed by +24V dc from the prime power source.

When prime power is restored, +24V dc from the prime power source picks K44 and K51 (ac on) and turns on the MAINLINE ON indicator. When the main K44 points close, the 208V ac input is restored into the C/I circuitry, and the K51 points pick K50 to start the various gate blowers.

The power control circuitry recognizes the restoration of main power by the pick of K13 (power restored) through the combination of K44 SSWA (ac on) and K15 N/O (on battery). Even though prime power is restored before the timeout period ends, battery power is used for the duration of the 6.5 seconds. Battery power is maintained by the K47 N/C points (on-battery limit) in parallel with the K13 N/C points (power restored). This circuit holds K52 and K54 picked within the line sense and switching circuitry. The K54 points allow the SCR to continue conducting and supplying battery power.

The battery power continues to flow until the 6.5 second timer times out. After this timeout period, the K47 N/C points open to drop K52 and K54. Battery power is removed when the K54 N/O points cause the SCR to turn



●Figure 3-7. IOCE Power Sequence and Control Circuitry

K12 PDU Thermal Catastrophic
K13 Power Restored
K14 Overvoltage/Overcurrent Hold
K15 On Battery
K16 CB Trip
K17 Power Fault Interlock
K22 +3 Volt Sense (Reg 6)
K23 +3 Volt Sense (Reg 7)
K24 +3 Volt Sense (Reg 15)
K25 -3 Volt Sense (Reg 13)
K26 +3 Volt Sense (Reg 10)

K27 -3 Volt Sense (Reg 2)
K28 +6 Volt Sense (Reg 3)
K29 +6 Volt Sense (Reg 4)
K30 +6 Volt Sense (Reg 8)
K31 +6 Volt Sense (Reg 16)
K32 +6 Volt Sense (Reg 1)
K33 -12 Volt Sense (Reg 14)
K34 +18 Volt Sense (Reg 12)
K35 +30 Volt Sense (Reg 11)
K36 +56 Volt Sense (Reg 9)
K37 +60 Volt Sense (Reg 5)

K42 Power Bit Interlock
K43 Master Power Off
K44 AC On
K45 Sequence Start Delay
K46 Sequence Interlock
K47 On Battery Limit
K48 +18V and -3V (Reg 12 and Reg 2)
K49 High Voltage On
K50 Blowers
K51 AC On

+18v -3v (II) P/S On
High Voltage On
Sequence Complete
Power Fault Interlock
On Battery
CB Trip
Thermal Reset
CLU Thermal Warning
Storage Thermal Warning
PDU Thermal Warning
CLU Thermal Catastrophic
Storage Thermal Catastrophic
PDU Thermal Catastrophic
Line Sense and Switching Circuit
Power Check
On Battery
To System Console
R/D8 R/D9 R/D10 R/D11
K48 K49 K4 K17 K16 K6 K7 K8 K9 K10 K11 K12 K15
K7 K8 K9 K14 K4 K16 K15
K10 K11 K12
R/D1 R/D2 R/D3 R/D5 R/D6 R/D7
J2-M J2-N J2-P J2-S J2-V J2-T J2-U
CLU Thermal
Store Thermal
PDU Thermal
Power Check
Sequence Complete
Open CB
On Battery
J2-X
K34 K27 K14 K17 K12 K11 K10 K5 K2 K3 K4
K35 K36 K37
K14
CB3 CB4 CB5 CB6 CB7 CB8 CB9 CB10 CB11
TB2
CB2-1 N/C
1 2 7 8
J1 D F
Converter/Inverter
J2-H
CLU Warning Thermals TH1-TH5 in Gates A, B, C, D, and E
J1-B
TH5 03J Gate
TH1 03J Gate
TH1 P/S
TH3 P/S
TH5 P/S
J2-K
CLU Catastrophic Thermals TH1-TH5 in Gates A, B, C, D, and E
J1-A
TH5 03J Gate
TH1 03J Gate
TH2 P/S
TH4 P/S
TH6 P/S
TB5
5 6
K54
K52
Thermal Reset
MACH Storage Thermal Warning
MACH Storage Catastrophic Thermals
J2-J J1-E J2-L J1-F
K7 K6 K8 K6 K9 K6 K10 K6 K11 K6 K12 K6 K27 K34 K47 K13
K2
K51 K47
Line Sense and Switching Circuit
TB5
RR1-1
9 10
Converter/Inverter
TB2
3 4
Thermal SSW2 N/C
Test OTC
Test OBS
TB100
6 3 2
Out of Tolerance Check
On Battery
Power-On Reset
To IOCE Circuit Logic
K9 K8 K7 K15 K3

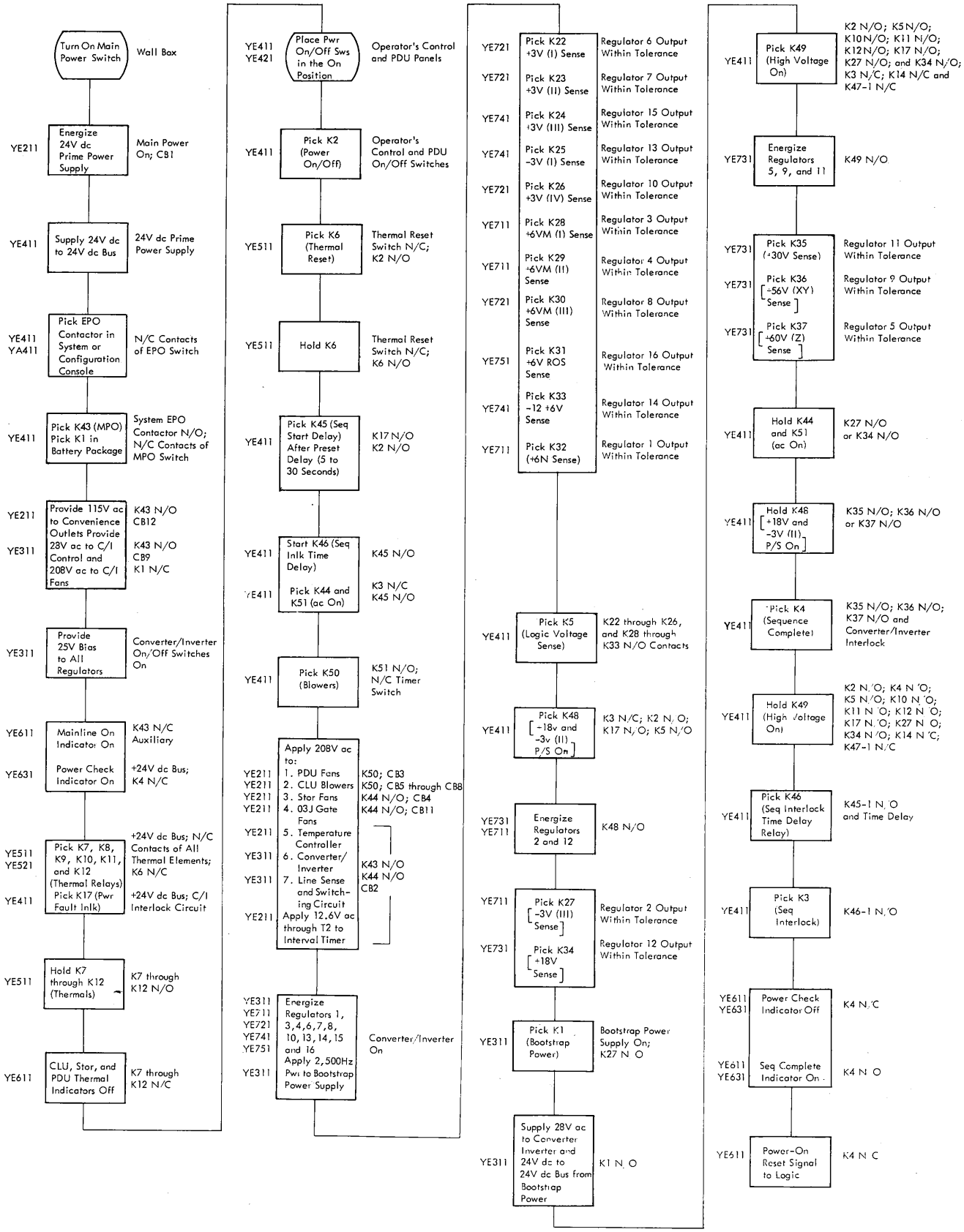

Turn On Main Power Switch
Wall Box
YE211
Energize 24V dc Prime Power Supply
Main Power On; CB1
YE411
Supply 24V dc to 24V dc Bus
24V dc Prime Power Supply
YE411 YA411
Pick EPO Contactor in System or Configuration Console
N/C Contacts of EPO Switch
YE411
Pick K43 (MPO) Pick K1 in Battery Package
System EPO Contactor N/O; N/C Contacts of MPO Switch
YE211
Provide 115V ac to Convenience Outlets Provide 28V ac to C/I Control and 208V ac to C/I Fans
K43 N/O CB12
YE311
K43 N/O CB9 K1 N/C
YE311
Provide 25V Bias to All Regulators
Converter/Inverter On/Off Switches On
YE611
Mainline On Indicator On
K43 N/C Auxiliary
YE631
Power Check Indicator On
+24V dc Bus; K4 N/C
YE511 YE521
Pick K7, K8, K9, K10, K11, and K12 (Thermal Relays)
+24V dc Bus; N/C Contacts of All Thermal Elements; K6 N/C
YE411
Pick K17 (Pwr Fault Inlk)
+24V dc Bus; C/I Interlock Circuit
YE511
Hold K7 through K12 (Thermals)
K7 through K12 N/O
YE611
CLU, Stor, and PDU Thermal Indicators Off
K7 through K12 N/C
YE411 YE421
Place Pwr On/Off Sws in the On Position
Operator's Control and PDU Panels
YE411
Pick K2 (Power On/Off)
Operator's Control and PDU On/Off Switches
YE511
Pick K6 (Thermal Reset)
Thermal Reset Switch N/C; K2 N/O
YE511
Hold K6
Thermal Reset Switch N/C; K6 N/O
YE411
Pick K45 (Seq Start Delay) After Preset Delay (5 to 30 Seconds)
K17 N/O K2 N/O
YE411
Start K46 (Seq Inlk Time Delay)
K45 N/O
YE411
Pick K44 and K51 (ac On)
K3 N/C K45 N/O
YE411
Pick K50 (Blowers)
K51 N/O; N/C Timer Switch
Apply 208V ac to:
YE211 1. PDU Fans K50; CB3
YE211 2. CLU Blowers K50; CB5 through CB8
YE211 3. Stor Fans K44 N/O; CB4
YE211 4. 03J Gate Fans K44 N/O; CB11
YE211 5. Temperature Controller
YE311 6. Converter/ Inverter
YE311 7. Line Sense and Switching Circuit
K43 N/O K44 N/O CB2
YE211
Apply 12.6V ac through T2 to Interval Timer
YE311 YE711 YE721 YE741 YE751 YE311
Energize Regulators 1, 3, 4, 6, 7, 8, 10, 13, 14, 15 and 16 Apply 2,500Hz Pwr to Bootstrap Power Supply
Converter/Inverter On
YE721
Pick K22 +3V (I) Sense
Regulator 6 Output Within Tolerance
YE721
Pick K23 +3V (II) Sense
Regulator 7 Output Within Tolerance
YE741
Pick K24 +3V (III) Sense
Regulator 15 Output Within Tolerance
YE741
Pick K25 -3V (I) Sense
Regulator 13 Output Within Tolerance
YE721
Pick K26 +3V (IV) Sense
Regulator 10 Output Within Tolerance
YE711
Pick K28 +6VM (I) Sense
Regulator 3 Output Within Tolerance
YE711
Pick K29 +6VM (II) Sense
Regulator 4 Output Within Tolerance
YE721
Pick K30 +6VM (III) Sense
Regulator 8 Output Within Tolerance
YE751
Pick K31 +6V ROS Sense
Regulator 16 Output Within Tolerance
YE741
Pick K33 -12 +6V Sense
Regulator 14 Output Within Tolerance
YE711
Pick K32 (+6N Sense)
Regulator 1 Output Within Tolerance
YE411
Pick K5 (Logic Voltage Sense)
K22 through K26, and K28 through K33 N/O Contacts
YE411
Pick K48 [-18v and -3v (II) P/S On]
K3 N/C; K2 N/O; K17 N/O; K5 N/O
YE731 YE711
Energize Regulators 2 and 12
K48 N/O
YE711
Pick K27 [-3V (III) Sense]
Regulator 2 Output Within Tolerance
YE731
Pick K34 [+18V Sense]
Regulator 12 Output Within Tolerance
YE311
Pick K1 (Bootstrap Power)
Bootstrap Power Supply On; K27 N/O
YE311
Supply 28V ac to Converter Inverter and 24V dc to 24V dc Bus from Bootstrap Power
K1 N/O
YE411
Pick K49 (High Voltage On)
K2 N/O; K5 N/O; K10 N/O; K11 N/O; K12 N/O; K17 N/O; K27 N/O; and K34 N/O; K3 N/C; K14 N/C and K47-1 N/C
YE731
Energize Regulators 5, 9, and 11
K49 N/O
YE731
Pick K35 (+30V Sense)
Regulator 11 Output Within Tolerance
YE731
Pick K36 [-56V (XY) Sense]
Regulator 9 Output Within Tolerance
YE731
Pick K37 [+60V (Z) Sense]
Regulator 5 Output Within Tolerance
YE411
Hold K44 and K51 (ac On)
K27 N/O or K34 N/O
YE411
Hold K48 [+18V and -3V (II) P/S On]
K35 N/O; K36 N/O or K37 N/O
YE411
Pick K4 (Sequence Complete)
K35 N/O; K36 N/O; K37 N/O and Converter/Inverter Interlock
YE411
Hold K49 (High Voltage On)
K2 N/O; K4 N/O; K5 N/O; K10 N/O; K11 N/O; K12 N/O; K17 N/O; K27 N/O; K34 N/O; K14 N/C; K47-1 N/C
YE411
Pick K46 (Seq Interlock Time Delay Relay)
K45-1 N/O and Time Delay
YE411
Pick K3 (Seq Interlock)
K46-1 N/O
YE611 YE631
Power Check Indicator Off
K4 N/C
YE611 YE631
Seq Complete Indicator On
K4 N/O
YE611
Power-On Reset Signal to Logic
K4 N/C

Figure 3-8. IOCE Power-On Flowchart

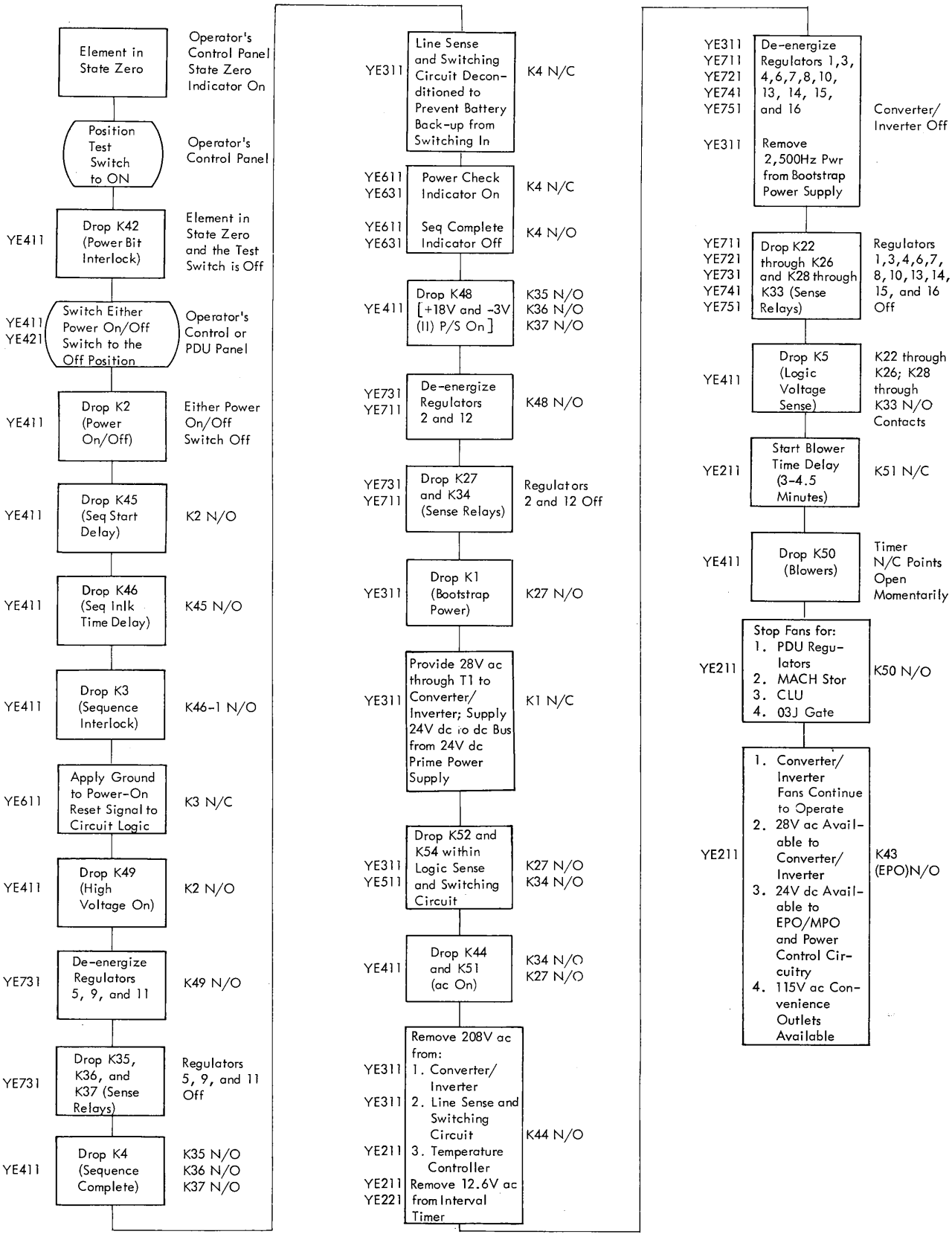


Figure 3-9. IOCE Power-Off Flowchart

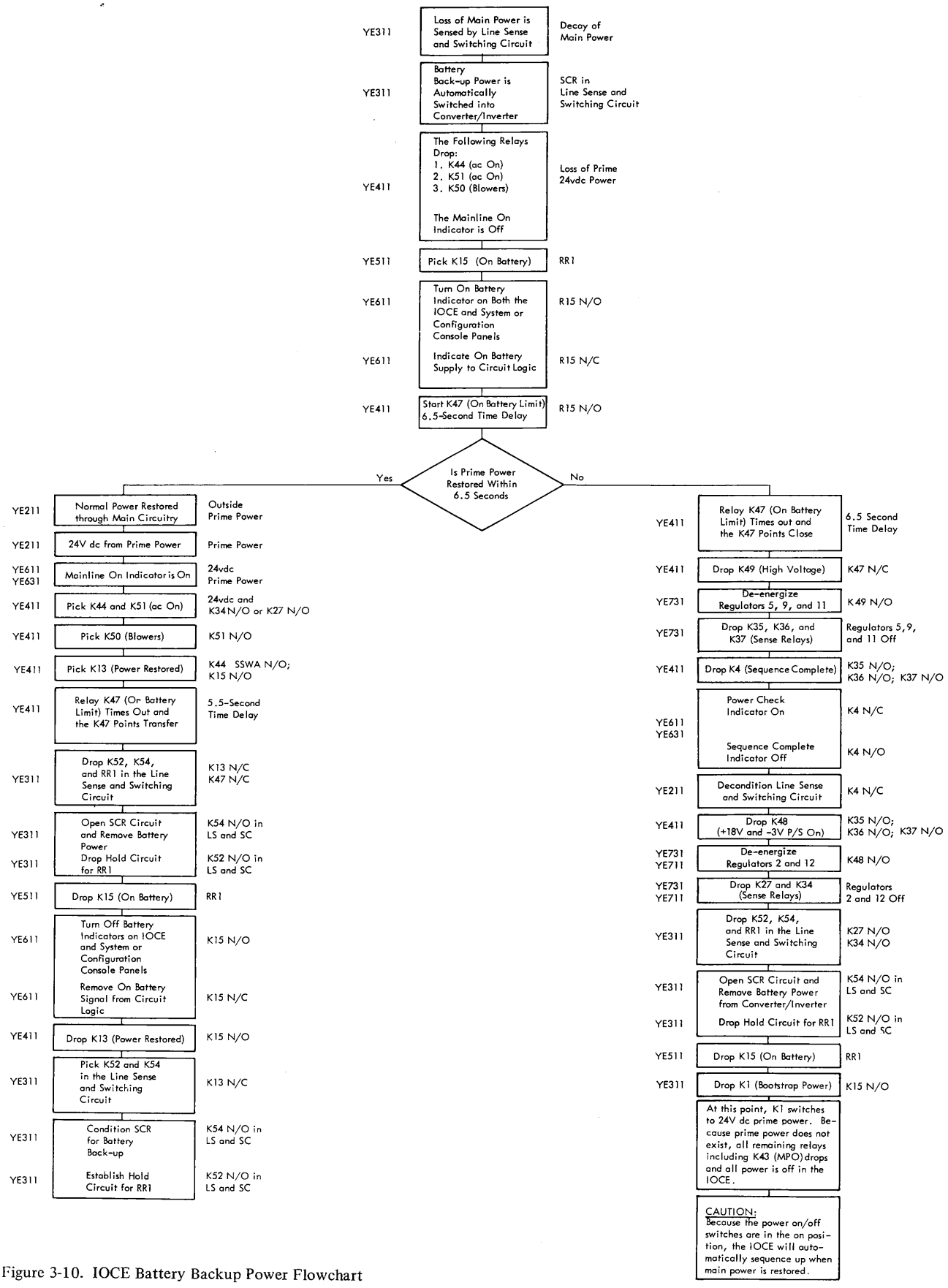


Figure 3-10. IOCE Battery Backup Power Flowchart

off by opening its anode circuit. The K52 N/O points break the hold circuit for RR1 in the line sense and switching circuit, and the RR1 N/O points cause K15 (on battery) to drop.

When K15 drops, the K15 N/O points break the hold circuit for K13 (power restored). When K13 drops, K52 and K54 in the line sense and switching circuit are repicked. The K54 points reapply potential to the anode of the SCR, enabling it to fire on demand from the sensing circuit and to provide a path for the battery backup power to the C/I. The K52 N/O points re-establish a hold circuit for RR1 when needed.

A power-off sequence is prevented from starting at the end of the 6.5-second timeout period by a set of K51 N/O points in the hold circuit for K49 (high voltage on). These K51 points (which closed with the return of prime power) provide a parallel circuit around the K47 N/C points which open at the end of the timeout period.

The system is again operating from prime power, the line sense and switching circuit has been re-established, and battery backup is ready for another emergency.

Battery Backup without Prime Power Restored

- 6.5 seconds of battery backup.
- Power is automatically sequenced off after 6.5 seconds.
- Power is automatically sequenced on when prime power returns.

When the SCR switches battery power into the IOCE, reed relay 1 (RR1) is picked in the line sense and switching circuit and provides a pick for K15 (on battery). As described in the preceding section, the points of K15 turn on a BATTERY indicator on the IOCE control panel and the system configuration console operator's panel. An 'on-battery' signal is also sent to the IOCE logic circuit. Switching to battery power also starts the 6.5-second on-battery limit time delay relay K47 (Figures 3-7 and 3-10).

If prime power is not restored within 6.5 seconds, K47 picks and power is sequenced off in three groups by opening the circuit for K49 (high voltage). Under normal power-off conditions, this circuit is broken by the N/O points of K2.

The K49 points open the 2500-Hz C/I power to the +30V, +56V, and +60V regulators. When these voltages decay and drop their respective sense relays, K48 (+18V and -3V) drops.

The K48 points open the 2500-Hz C/I power to the middle group of dc voltage regulator supplies. When these two supplies decay, their respective sense relays (K34 and K27) drop. When K27 and K34 drop, the N/O points of these relays drop K52 and K54 in the line sense and switching circuit. K54 opens the SCR circuit which supplies the battery power to the C/I, and K52 opens the hold circuit for RR1. When RR1 points open, K15 is dropped which drops K1 (bootstrap supply). The K1 points try to return the IOCE to prime +24V dc power; because there is no prime power available, all relays drop including K43 (MPO) and K1 (in the battery package). The only power available is within the battery package.

Under these power-off conditions, when no prime power is available, the POWER CHECK indicators on the IOCE control panel and console operator's panel are not on.

CAUTION

Note that under these conditions the POWER ON/OFF switches are set to ON. With these switches on, power is automatically sequenced up again when main power is restored.

Emergency Power-Off Sequence

- EPO/MPO conditions immediately remove all power, except +24V dc prime.
- Normal power-off sequencing is bypassed.
- Battery backup is prevented under EPO/MPO conditions.

If either the system EPO or the IOCE MPO pull switch is pulled, all power is turned off beyond the entry terminals, except the +24V prime power supply. The EPO/MPO switches are mechanical latch-type switches that must be reset manually.

Pulling either the EPO or MPO switch causes K43 (MPO) and K1 (in the battery package) to drop in the IOCE (Figure 3-4). The main K43 points immediately remove all power to the IOCE circuitry, and the K43 SSWA and SSWB points remove all +24V dc control voltage to the relays and contactors.

With all power removed, normal power-off sequencing cannot occur and all regulator power falls simultaneously. Dropping K1 in the battery package also prevents any high dc voltages from getting outside the battery package.

Under EPO/MPO conditions, +24V dc power is still within the power interlock cable that connects the IOCE and the console. This voltage is necessary so that power can sequence up automatically when the EPO/MPO condition is removed.

Special Power-Off Sequences

Regulator Undervoltage Power-Off Sequence

- Each regulator output has a sense relay.
- Undervoltage conditions automatically sequence power off.
- Power does not sequence up until POWER ON/OFF switch is turned off and then on.
- The undervoltage sense system immediately grounds the +56V and +60V supplies.

Each IOCE regulator (Figure 3-6) has an associated regulator output sense relay. Each sense relay ensures that the associated regulator output is at the proper amplitude required for normal element operation. For example, the outputs from regulators 1, 3, 4, 6, 7, 8, 10, and 13–16 are sensed by relays K22–K26 and K28–K33. If any of these logic voltage sense relays drop, relay K5 also drops. The K5 N/O points drop K49 (high voltage) and begin a normal power-off sequence.

After power has sequenced off, K2 (power on/off) remains picked because POWER ON/OFF is still set to ON. If K2 does not drop, K45 (sequence start time delay) cannot drop. The K45 N/O points hold K46 (sequence interlock time delay) which holds K3 (sequence interlock). The K3 N/C points prevent power from automatically sequencing up again until POWER ON/OFF is turned off and then on.

Undervoltage conditions in the two other voltage groups also start the power-off sequence. An undervoltage condition in the middle group is detected by K27 and K34 from regulators 2 and 12. When either relay drops, K49 (high voltage) drops, initiating a normal power-off sequence.

Undervoltage outputs from regulators 11, 9, and 5 are sensed by relays K35, K36, and K37, respectively. When any of these relays drop, K4 (sequence complete) drops which drops K49 (high voltage) for a normal power-off sequence.

These two latter cases also require that POWER ON/OFF be turned off and then on to sequence power up again. In all cases, the K4 N/C points (ALD page YC311) decondition the line sense and switching circuit to prevent the battery backup supply from sustaining power for an additional period of time.

Overvoltage/Overcurrent Power-Off Sequence

- Each regulator has an overvoltage/overcurrent (OV/OC) sense relay.
- An OV/OC condition automatically sequences power off.
- Power does not sequence up until regulator is reset and POWER ON/OFF is turned off and then on.
- Battery backup is prevented under OV/OC conditions.

Each IOCE regulator has an overvoltage/overcurrent (OV/OC) sense relay. If an OV/OC condition occurs in a given regulator, its respective sense relay (a reed relay on the OV/OC SMS card) is picked. The N/O contacts of any of the picked sense relays (Figure 3-7) pick K14 (OV/OC hold). The K14 N/O points open the circuit to K49 (high voltage) and a normal power-off sequence is started. After power has been sequenced off, K2 (power on/off) remains picked because POWER ON/OFF is still set to ON.

When K14 picks, the K14 N/C points cause K17 (power fault interlock) to drop. To restore power to the IOCE, the OV/OC condition must be reset manually at the C/I, and POWER ON/OFF must be turned off and then on.

Pressing RESET at the C/I drops the OV/OC reed relay at the regulator. These RR N/O points open the pick (and hold) circuit for K14. K14 continues to hold, however, through the POWER ON/OFF switches. When a POWER ON/OFF switch is turned off, K2 and K14 drop and K17 (power fault interlock) picks. When POWER ON/OFF is turned on, K2 picks and a normal power-on sequence is started.

If the OV/OC condition is not reset before the POWER ON/OFF switches are set, K14 continues to hold through the N/O RR points. With K14 picked, K17 is held dropped, and the K17 N/O points prevent K45 (sequence start time delay) from starting the power-on sequence.

In all cases of OV/OC, the K4 N/C points decondition the line sense and switching circuit (ALD page YC311) to prevent the battery backup supply from sustaining power for an additional period of time.

Note: When RESET is pressed at the C/I, hold it for a few seconds. A momentary depression is not enough time to reset the OV/OC reed relay and gives the false impression of a second OV/OC condition.

Thermal Check Power-Off Sequence

- A catastrophic thermal condition immediately sequences power off.
- A thermal warning condition does not sequence power off.

- Power is not sequenced up until thermals are reset and POWER ON/OFF switch is turned off and then on.

- Battery backup is prevented under catastrophic thermal conditions.

Two types of thermal checks (thermal warning and thermal catastrophic) can occur in the IOCE. The first check (thermal warning) occurs when the IOCE operating temperature in the storage area is 112°F but less than 125°F, or when the operating temperature in the CLU is 120°F but less than 130°F, or when the operating temperature in the PDU is 130°F but less than 140°F. The storage thermal warning sensing devices control relay K8; the CLU and PDU thermal warning sensing devices control relays K7 and K9, respectively (Figure 3-7).

When a thermal warning condition is in either the CLU, PDU, or storage, the associated thermal warning relay is dropped. The related THERMAL indicator on the operator's control panel is turned on, a +24V dc signal is routed to the POWER CHECK indicator on the system or configuration console, and an 'out-of-tolerance' (OTC) check signal is applied to the IOCE logic circuit. This OTC signal immediately causes an element check (ELC) signal in each CE to inform the executive control (EXC) program.

Note that a thermal warning condition does not cause a POWER CHECK indication at the IOCE nor does it initiate a power-off sequence.

The second check (thermal catastrophic) occurs when the operating temperature in the storage area exceeds 125°F, when the operating temperature in the CLU exceeds 130°F, or when the operating temperature in the PDU exceeds 140°F. The storage thermal catastrophic sensing devices control relay K11; the CLU and PDU thermal catastrophic devices control relays K10 and K12, respectively.

When a thermal catastrophic condition is in either the CLU, PDU, or storage, the associated thermal catastrophic relay is dropped. The N/C contacts of the dropped relay turn on the associated THERMAL indicator and provide a +24V dc signal to the POWER CHECK indicator on the console. The N/O contacts of relay K10, K11, or K12 interrupt the return for the relay K49, causing this relay to drop.

Relay K49 N/O contacts initiate a normal power-off sequence. The power-off sequence turns on the IOCE POWER CHECK indicator through the K4 N/C points. After power has sequenced off, K2 (power on/off) remains picked because POWER ON/OFF switch is still set to ON.

To restore power to the IOCE, the thermal condition must be reset and POWER ON/OFF must be turned off and then on. A THERMAL RESET pushbutton is provided to reset the thermal relays. When THERMAL RESET is pressed after the temperature in the overheated area(s) has fallen below the warning level, the associated thermal relay picks, causing the related THERMAL indicator to be turned off.

Setting POWER ON/OFF to OFF drops K2, K45, K46, and K3. Setting POWER ON/OFF back to ON causes the normal power-on sequence to begin.

If the thermal condition is not reset before operating POWER ON/OFF, power sequences up through the middle voltages but not through the high voltages. When K3 (sequence interlock) picks after the K46 (sequence interlock) time delay, the K3 N/C points cause power to sequence off.

In all catastrophic thermal conditions, the K4 N/C points decondition the line sense and switching circuit (ALD page YC311) to prevent the battery backup supply from sustaining power for an additional period of time.

Sequence Interlock Power-Off Sequence

- Power is automatically sequenced off if all voltages are not sequenced up within a specified period of time.

- Battery backup is deconditioned during a sequence interlock condition.

Power on the IOCE should completely sequence up within about 10 seconds. If, for some reason, one or more of the regulators fail to operate, power is automatically sequenced off. This automatic power-off sequence is accomplished by K46 which is set for a time delay that is slightly longer than the time necessary to sequence power up. When K46 times out, K3 (sequence interlock) picks. Relay K3 is a logical extension of K46 to provide the necessary number of relay points required for the control circuitry.

If power has completely sequenced up, hold circuits have been established for K44 (ac on), K48 (middle voltage group), and K49 (high voltages). If power has not completely sequenced up, these hold circuits have not been established. The K3 N/C points open the pick circuits for these three relays and cause a normal power-off sequence.

To start another power-on sequence, POWER ON/OFF must be turned off and then on. Because K4 was never picked, the line sense and switching circuit remains deconditioned, and the battery backup supply is prevented from sustaining power.

PDU Circuit Breaker Trip

- Concerned primarily with blower motors.

- Does not cause a power-off sequence.

The IOCE has an OPEN CB indicator which indicates a tripped circuit breaker in the PDU. If any of circuit

breakers CB3–CB11 trips, relay K16 picks. The K16 N/O points turn on the IOCE OPEN CB indicator but do not affect the power check indicators on the IOCE or on the system or configuration console.

The circuit breakers are concerned primarily with blower motors; therefore, they do not cause a power-off sequence. If the blower is not restored, however, the temperature in the affected area rises until the thermal contacts in that area close. The thermal warning contacts notify the logic circuit (Figure 3-7); the catastrophic thermals cause power to sequence off.

CONTROLS AND INDICATORS

The following controls and indicators are associated with IOCE power. Controls and indicators are on the operator's control panel and on the PDU. The operator's control panel and the PDU are described separately.

Operator's Control Panel

The controls and indicators associated with IOCE power are on the upper left and lower right sections of the panel. the ELEMENT MPO PULL switch is on the upper right corner of the panel.

ELEMENT MPO PULL Switch

Pulling the ELEMENT MPO PULL switch causes all IOCE power to be removed within 2 seconds. However, power is still present at the IOCE entry terminal and at the +24V prime power supply.

Note: the ELEMENT MPO PULL switch is a mechanical latch-type switch that must be reset manually. After the switch is reset, power automatically sequences up if the POWER ON/OFF switches are set to ON.

POWER ON/OFF Switch

The POWER ON/OFF switch begins the power on/off sequence for the IOCE. After the completion of a power-on sequence, this switch is effective only when the IOCE is in state zero and the TEST switch is set at the on position. the POWER ON/OFF switch is connected in series with the PDU POWER ON/OFF switch.

POWER SEQUENCE COMPLETE Indicator

The POWER SEQUENCE COMPLETE indicator is on when the power sequence to the IOCE is complete. This indicator is turned off when the first power supply is sequenced off during a power-down operation.

IOCE Power Indicators

The seven IOCE power indicators function as follows:

THERMAL – CLU, STOR, and PDU: The corresponding indicator is on when the upper limit (warning or catastrophic) temperature is exceeded in the CLU, storage (STOR), or PDU.

MAINLINE ON: Is on when prime power is available and the main IOCE circuit breaker is on. This indicator is independent of POWER ON/OFF switch operation but is not on under EPO/MPO conditions.

BATTERY: Is on when the IOCE has switched to battery power. This indicator turns off when main power switches back.

OPEN CB: Is on when one or more blower motor circuit breakers (CB3–CB11) are open.

POWER CHECK: Is on when one or more of the following conditions exist in the IOCE power system:

1. A catastrophic power failure has occurred (OV/OC, undervoltage, or sequence interlock condition).
2. A catastrophic thermal condition has sequenced power off.
3. A normal power-off operation has occurred.

STATE Indicators

The four STATE indicators reflect the operational state of the element (state three, two, one, or zero). The IOCE must be in state zero before a normal power-off sequence can begin.

TEST Switch

The TEST switch is effective when the IOCE is in state zero. This switch must be on before a normal power-off sequence can begin.

Voltmeter

The voltmeter monitors the selected marginal voltage or the selected monitor voltage.

MONITOR VOLTAGE SELECT Rotary Switch

The MONITOR VOLTAGE SELECT switch selects the non-marginal voltages. The MARGIN VOLTAGE SELECT switch must be set at MONITOR SELECT to activate this switch. The following voltages and regulators can be selected:

Regulator	Voltage
1	+6
2	-3 No. 2
6	+3 No. 1
7	+3 No. 2
10	+3 No. 4
11	+30
12	+18
13	-3 No. 1
14	-12
15	+3 No. 3

MARGIN VOLTAGE SELECT Rotary Switch

The MARGIN VOLTAGE SELECT switch selects the marginal voltage to be monitored on the meter. The MONITOR SELECT position of this switch also activates the MONITOR VOLTAGE SELECT switch. The following marginal voltages and regulators can be selected:

Regulator	Use
16	+6 TC (temperature compensation—local storage)
16	+6 VAR (variable—local storage)
16	+6 ROS (read only storage)*
3	+6 M1 (variable—CLU)
4	+6 M2 (variable—CLU)
8	+6 M3 (variable—CLU)
9	+56 XY (maintenance and channel storage—XY drivers)
5	+60 Z (maintenance and channel storage—Z drivers)

Marginal Voltage Control

The marginal voltage control allows the marginal voltage to be varied above and below its nominal value. One set of controls is used for each MARGIN VOLTAGE SELECT switch position. More than one voltage can be varied at one time.

*Set to 6.3V. Not to be used for marginal checking.

Marginal Voltage Indicators

The marginal voltage indicators are on when a marginal voltage is varied from its nominal value. A separate indicator is used for each marginal voltage control.

PDU

The PDU controls and indicators are on the front of the lower frame door panels. Controls and indicators on the regulators and C/I are described in the Field Engineering Theory of Operation manual, IBM SLT Power Supplies.

Circuit Breakers

CB1 (Mainline circuit breaker): controls the 3-phase, 208V ac, 60-Hz input to the IOCE that is applied from the customer's ac service.

CB3: controls input to PDU power regulator fans.

CB4: controls input to storage fans.

CB5—CB8: control inputs to blowers in gates A, B, C, and E within the CLU.

CB9: controls input to the C/I blowers and input to transformer T2 which supplies 28V ac input power to the C/I.

CB10: controls input to the 3 to 4.5 minute blower timer motor.

CB11: controls input to blowers located on 03J gate in the PDU.

CB12: controls input to the convenience outlets in the PDU, CLU, and storage.

POWER ON/OFF Switch

The POWER ON/OFF switch begins the power on/off sequence in the IOCE. After completion of a power-on sequence, this switch is effective only when the IOCE is in state zero and the TEST switch is set to ON. The PDU POWER ON/OFF switch is connected in series with the POWER ON/OFF switch on the operator's control panel.

THERMAL RESET Pushbutton

Pressing THERMAL RESET resets the thermal relays that are controlled by the thermal sensing elements within the CLU, PDU, and MACH storage. Pressing this pushbutton also turns off the corresponding THERMAL indicators if the related temperature has fallen below the warning level.

TEST OBS Pushbutton

Pressing TEST OBS simulates an on-battery condition by forcing an 'on-battery' signal into the IOCE logic circuit. This signal is transmitted to the DAR register in each system CE where the monitor program can test the condition.

TEST OTC Pushbutton

Pressing TEST OTC simulates a thermal warning condition in the IOCE by forcing an OTC signal into the IOCE logic circuit. This signal is transmitted into the DAR register in each system CE where the monitor program can test the condition.

Fuses F1 and F2

Fuses F1 and F2 protect the +24V prime power supply and its associated circuits from overload.

All 7251-09 Storage Element (SE) components and circuits associated with power distribution and control are described in this chapter. A general description of protection and checking circuits (including EPO/MPO) and battery backup power is given in Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- The SE consists of five frames.
- Frame 1 contains SSU power supplies and associated components.
- Frame 5 contains storage power supplies and associated components.
- Four functional units in SE power: converter/inverter, regulators, battery backup supply, and control circuitry.

The SE consists of two basic storage areas. Frames 1 and 2 make up the storage switching unit (SSU): frames 3, 4, and 5, the storage section. Each section has its own power supplies. Frame 1 contains the power components for the SSU; frame 5, the power components for the storage section.

The major functional units of SE power are the 75-amp converter/inverter (C/I), the dc regulators, the battery backup supply, and the control circuitry. The C/I converts 208V ac, 60-Hz, 3-phase, input power to single-phase, square-wave, 2500-Hz power. The dc regulators convert the 2500-Hz power from the C/I into the regulated dc power required by the SE. The battery backup system keeps the C/I running for 5.5 ± 0.5 seconds in case of an ac input line failure. The power control circuitry provides power control, protection, and distribution. It also satisfies power sequencing required within the SE.

The C/I, the battery backup supply, and the dc regulators are standard units used in other elements of the system (see Chapter 1). This chapter describes the components unique to the SE as well as all the SE power controls.

Figures 4-1 through 4-6 show the locations of the various components within the SE. Figure 4-1 shows an overall view of the SE. Frame 1 is in front of the SE and in conjunction with adjacent units, forms the power wall of the system. Frame 1 contains the power supply components for the SSU. The power supply tub assembly located on frame 1 contains the six dc regulators, A1 through A3 and B1 through B3. The SSU power control panel and the SSU power sequencing relays are also located in this frame. The SE master power-off switch (MPO) is located at the upper left portion of frame 1, and the I/O panel is located at the bottom. Frame 1 is mounted on hinges and equipped with a latch to permit access to the rear of the frame and to the tailgate (containing the element I/O cables) located on frame 2. With all machine covers on, the MPO switch is the only operator accessible component.

Frame 5 is at the rear of the SE and contains the C/I, the battery backup system, storage section dc regulators, and much of the power control circuitry. The dc regulators are contained in three power tubs. The inner tub is permanently mounted in the center of frame 5 and contains regulators 1–11. The swinging power tub contains regulators 12–18, and the remaining power tub at the rear of the SE contains regulators 19–22. Also located on frame 5 are the line sense and switching circuitry, the prime power panel, and the power control panel.

Power Interlock Circuitry

- Power can be removed from the SE by: (1) system EPO switch, (2) element MPO switch, (3) removing 208V ac prime power input or, (4) turning the machine off.

With the TEST/NORMAL switch in NORMAL, power can be turned off by removing the prime power at the facility source, by operating the system EPO switch located on the system or configuration console, or by operating the element MPO switch at the top of frame 1. When the TEST/NORMAL switch is in NORMAL, interrupting the 208V ac power input results in a transfer to the battery backup supply for 5.5 seconds. If 208V ac input power is not restored during this time, a power-down sequence follows; if input power is restored during the 5.5-second period, the SE reverts to operation on 208V ac input power after 5.5 seconds.

Both the system EPO switch and the element MPO switch are mechanically interlocked so that, if either is operated, it must be reset by maintenance personnel. Power down as a result of operating the system EPO switch or the element MPO switch does not follow the normal power-off sequence. As shown in Figure 4-7, relay K1 (EPO control) drops whenever either of these switches is operated. Prime

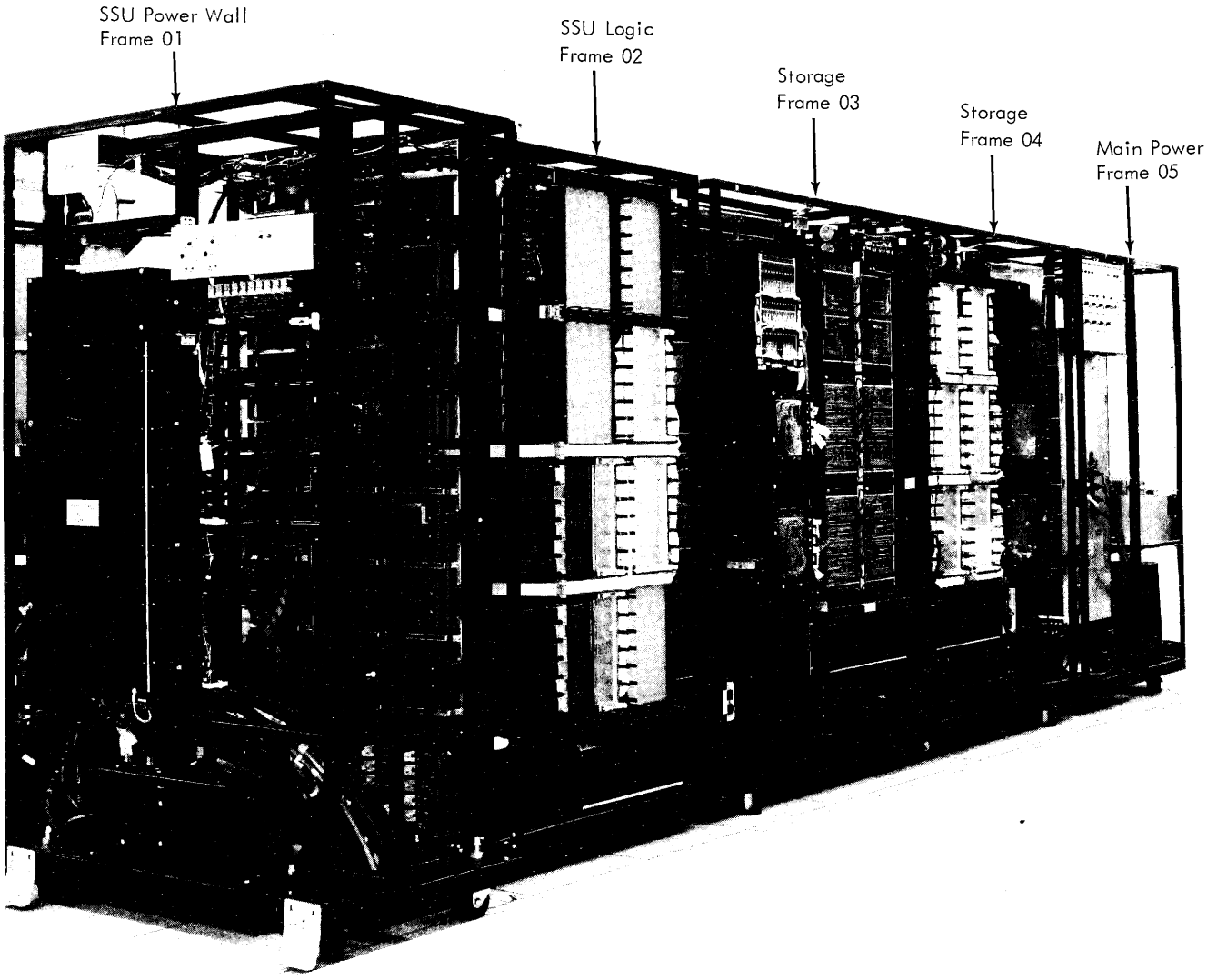
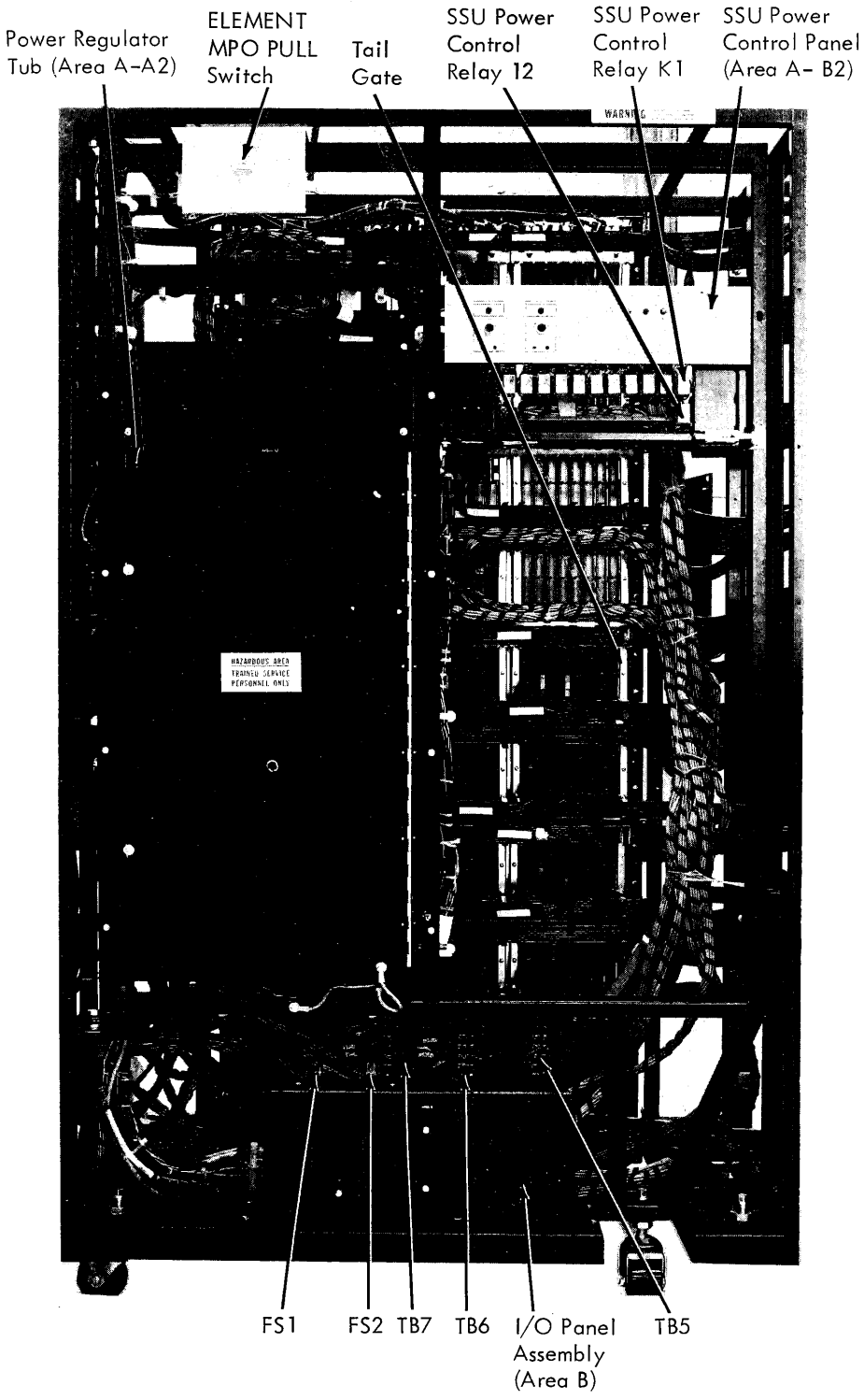


FIGURE 4-1. STORAGE ELEMENT FRAME IDENTIFICATION



●Figure 4-2. SSU Power (Frame 1)

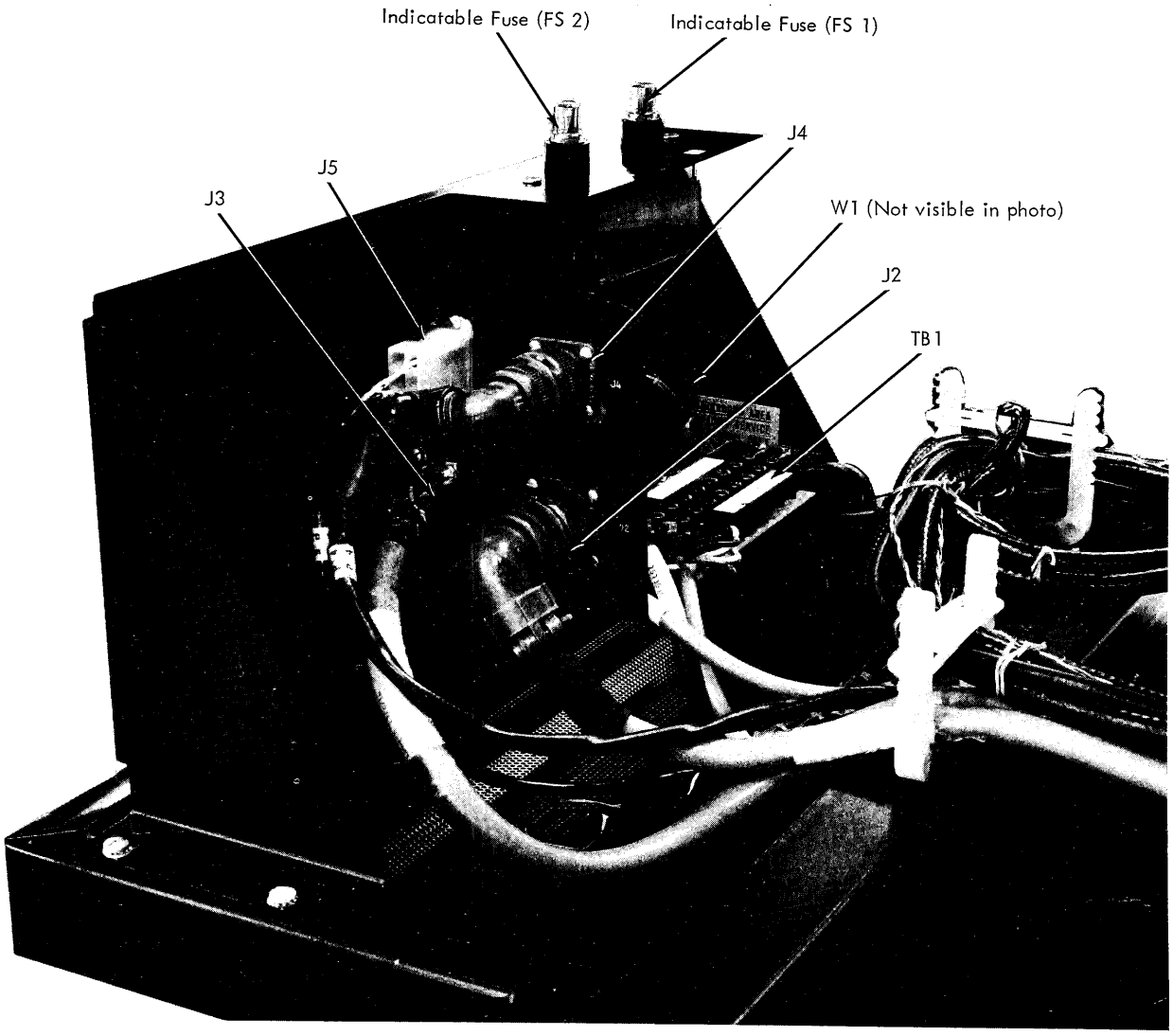
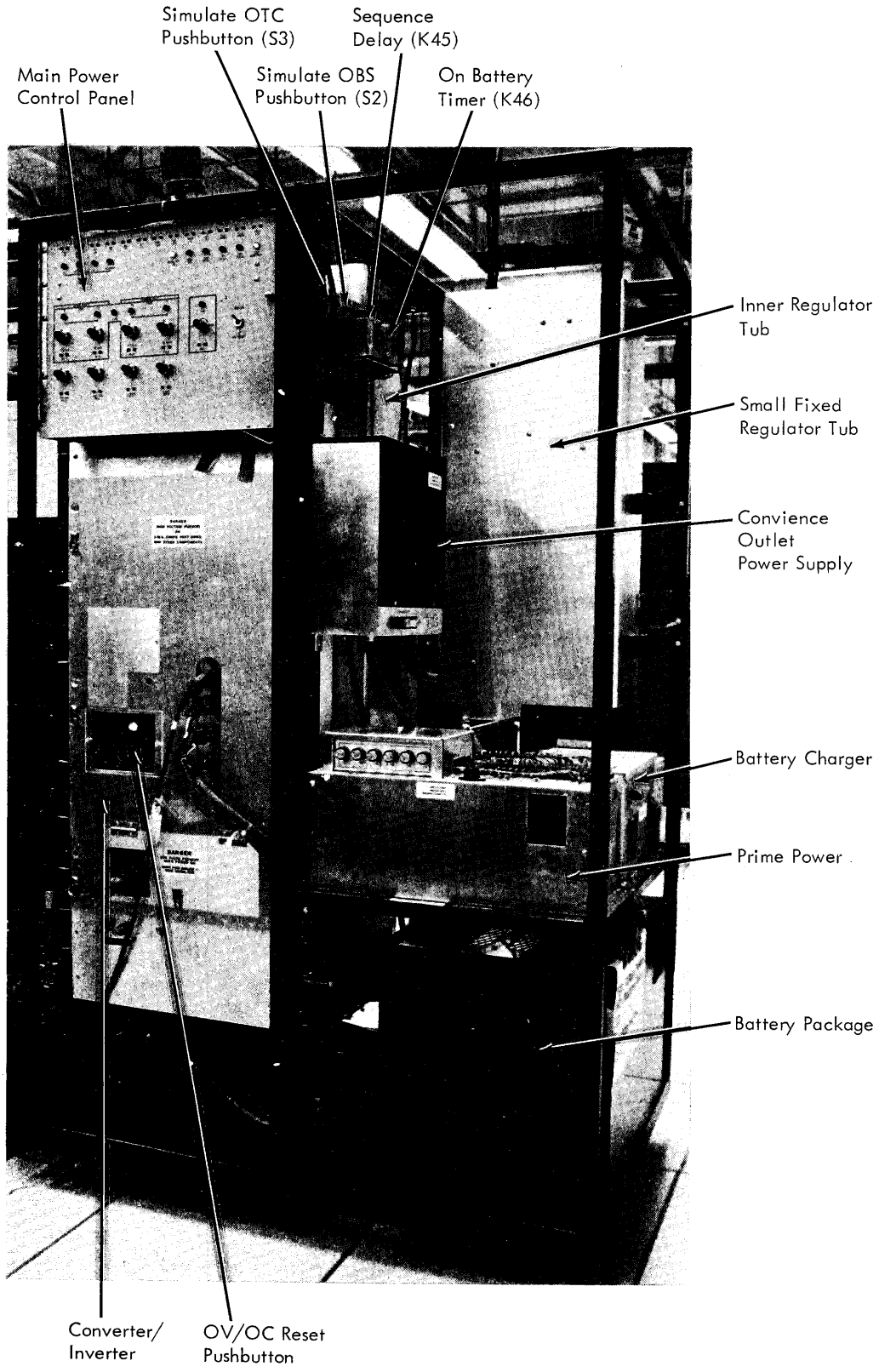


FIGURE 4-3. SSU I/O POWER PANEL



●Figure 4-4. Storage Power (Frame 5)

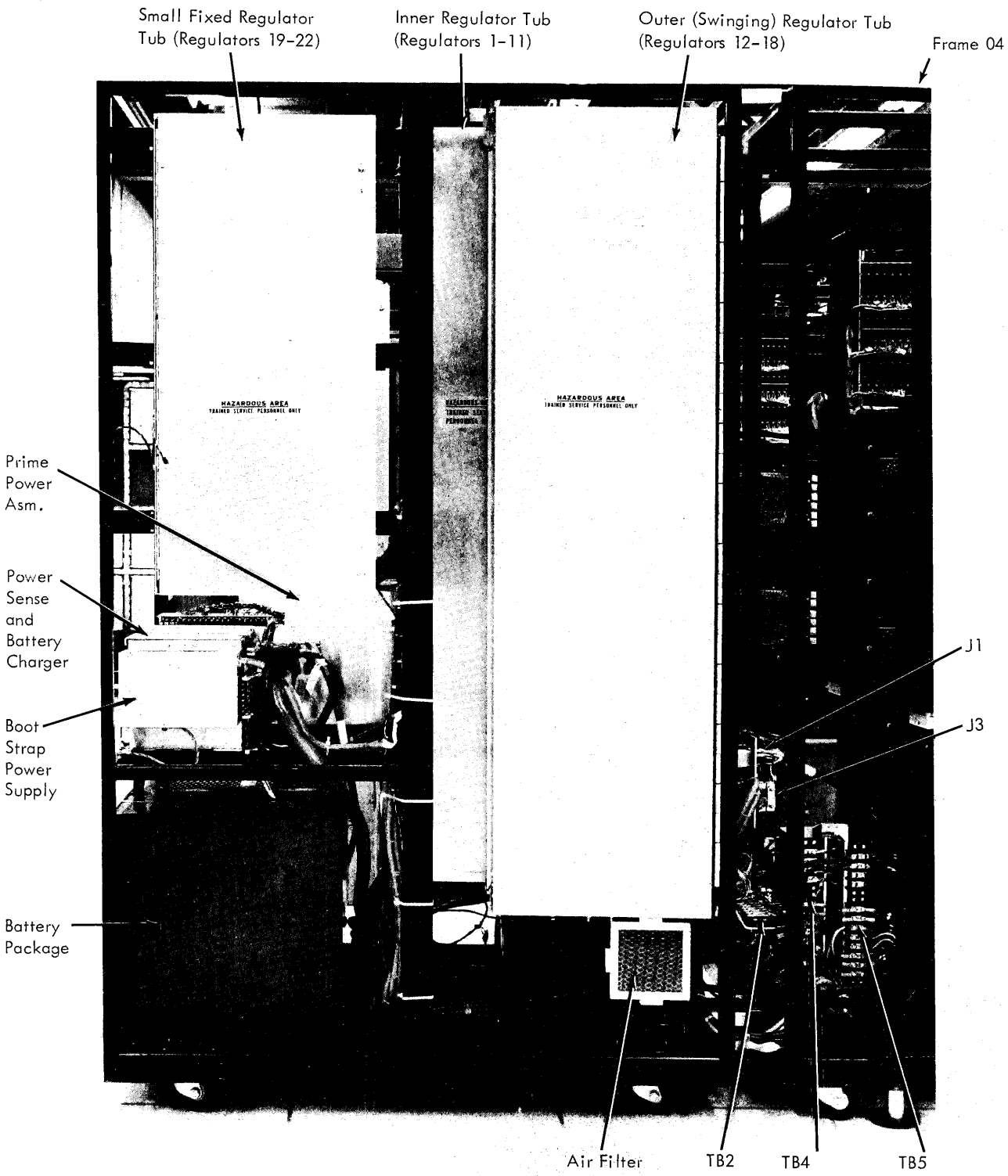


Figure 4-5. Storage Power, Frame 5 (Left Side View)

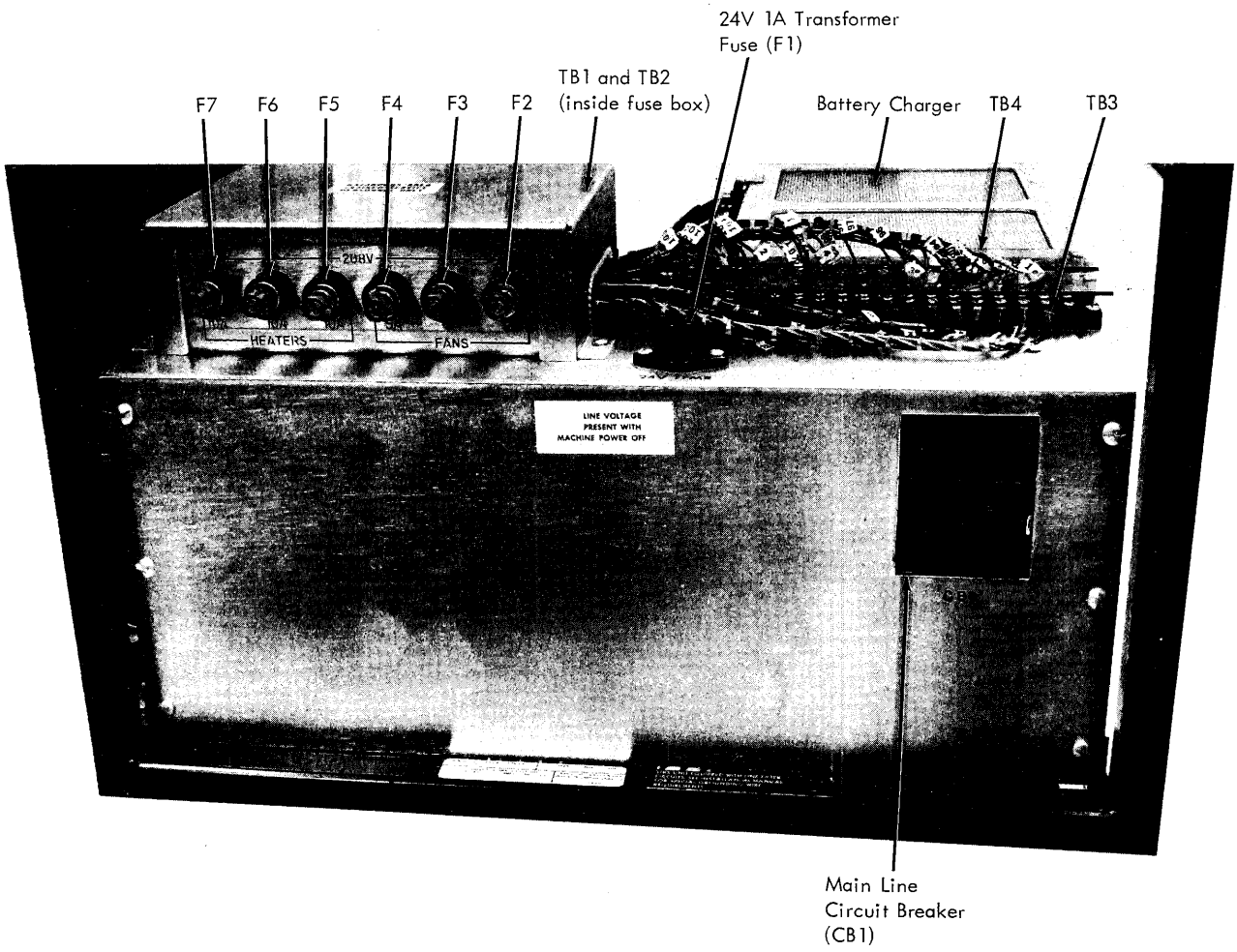


Figure 4-6. Storage Prime Power

power is immediately removed and all the regulators are disconnected. The convenience outlets are also deactivated because K47 (convenience outlet control) drops in parallel with K1 (EPO control).

With both the EPO and MPO switches reset (normal state), relay K1 is picked when the SSU and storage thermal relays have been picked. The power-on sequence begins when the PWR ON switch is activated.

Manual power-off under control of the PWR ON/OFF/RESET switch on the power control panel can be accomplished only when the TEST/NORMAL switch is at TEST and the SE is in state zero.

AC Distribution

- 208V ac, 3-phase, 60-Hz input voltage.
- Mainline circuit breaker rated at 40 amp.
- +24V present when mainline circuit breaker is on.
- Two mainline contactors distribute 208V ac to storage and SSU sections.
- Mainline voltage is monitored by a line sense relay.

Input voltage to the SE is 208V ac, 3-phase, 60-Hz supplied by a four-wire cable. (The fourth wire is a non-current carrying equipment ground.) Maximum rms input current is 21 amperes at 208V. The input circuit breaker (CB1) protects the SE components from damage when short circuits occur. This circuit breaker opens the mainline when 40 or more amperes are drawn.

The ac power distribution and control circuitry is shown in Figure 4-8. CB 1 controls all ac input voltage to the SE. Turning CB 1 on applies single-phase 208V ac through fuse F1 to the input of the 24V prime power supply. The MAIN LINE ON indicator lights when CB1 is on and K1 is closed,

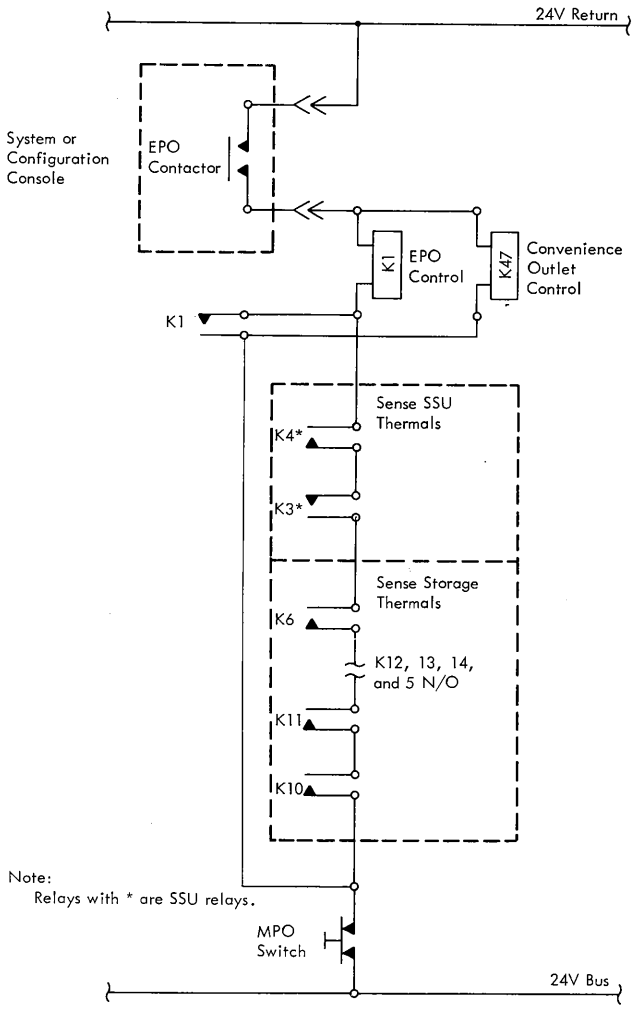


Figure 4-7. SE Power Interlock Circuitry

+24V dc is available, and convenience outlet power is available. Bias is present at all dc regulators when the 24V prime power supply is energized.

Power-on contactors K41 and K42 must be energized for any further distribution of the input ac voltage to occur. Pick voltage is applied to K41 and K42 in parallel through the K4 N/O points. K4 (C/I start relay) is energized during the power-on sequence. The power-on sequence is described later in this chapter.

When contactor K41 (power on) is energized, 208V ac is applied to: the C/I (via plug P1 and jack J1), the line sense and switching circuitry (at TB-6), and to the storage section fans (through fuses F2, F3, and F4).

Power-on contactors K42, picked in parallel with K41, provides 208V ac to the SSU power fan and the SSU gate blowers. Voltage is also applied to the storage section heaters through 10-amp fuses F5, F6, and F7.

Line sense relay K40 picks through an N/O point on contactor K41. Points of the line sense relay are used by the battery-on and battery-off sequences to indicate the presence or absence of prime power.

DC Distribution

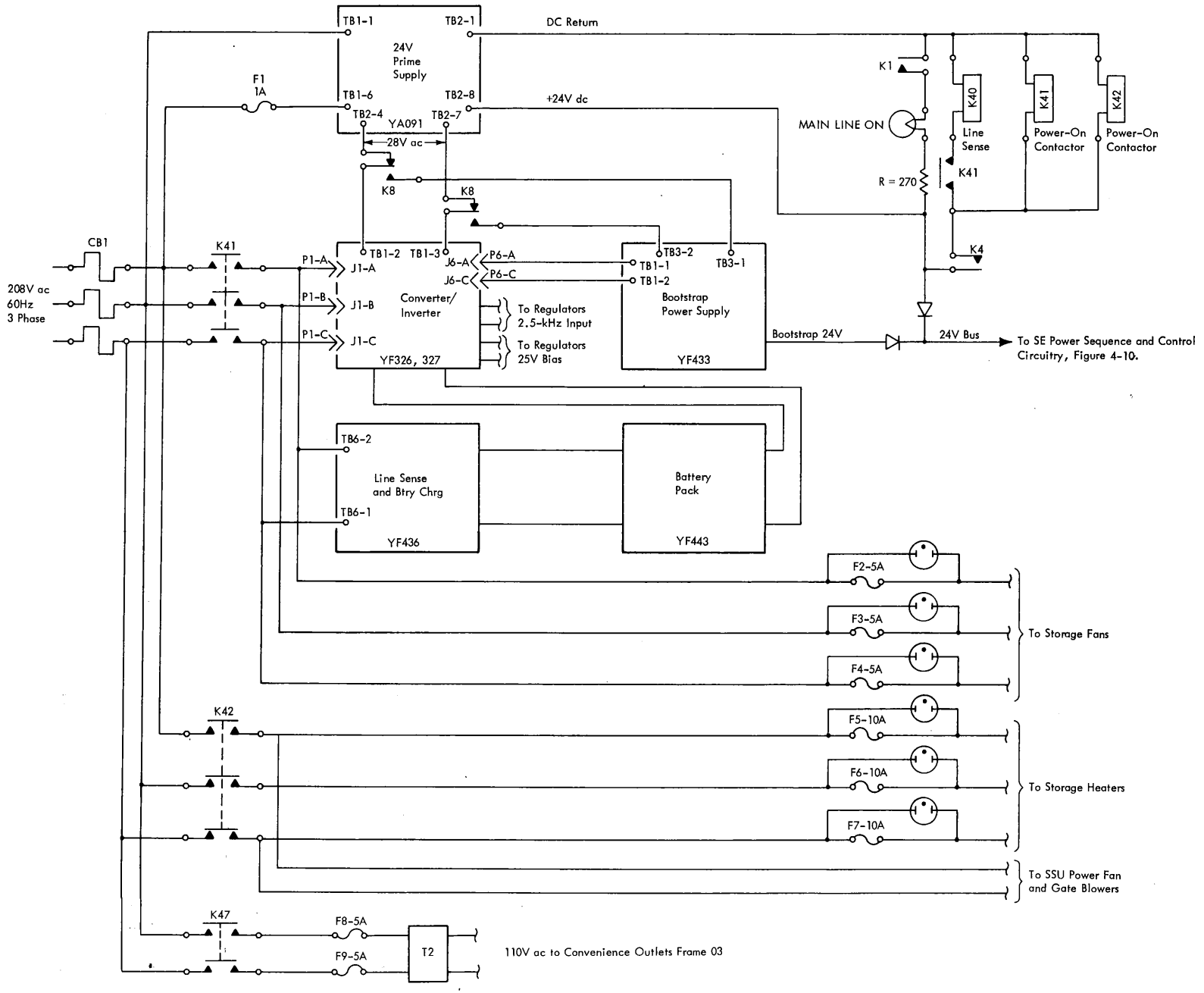
- All dc logic voltages derived from dc regulators.
- 28 regulators are used in the SE.
- 137V (rms), 2.5-kHz square wave from C/I power regulators.
- Low-voltage regulators sequence on first.
- High-voltage regulators sequenced on last.
- Storage protect supplies (regulators 12 and 13) powered by regulator 8.
- All regulator outputs are relay sensed.
- Regulator power supply tubs are protected by thermal sensors that detect over-temperature condition.

Figure 4-9 shows the SE dc regulator supplies and controls. All dc voltages used by the SE except the power sequence and control voltage are obtained from the SE regulators. The SE uses 28 dc regulators.

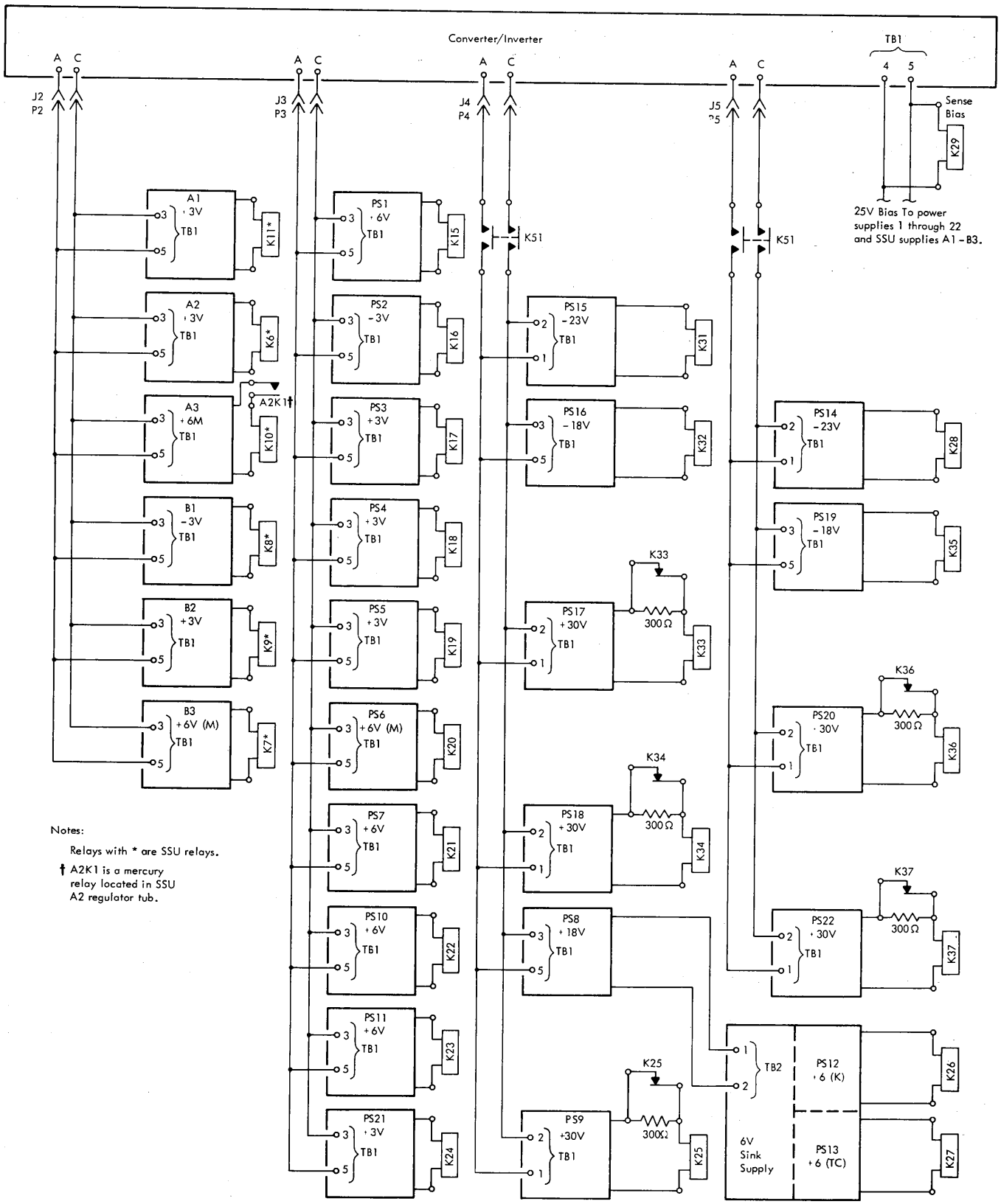
Circuitry in the individual regulators provides the desired dc output voltage. Regulator output current and voltage is monitored to protect the regulators. Should either the current or the voltage exceed the upper limit, a short circuit (axe) is placed across the output, the regulator shuts off, and the sequence and control circuitry is signalled to begin a power-down sequence.

Each regulator output (except PS8) is monitored by a sense relay which also controls the proper power-on and power-off sequencing in the SE. The sense relays are connected directly across the output of the regulators. The HV regulators have a 300-ohm resistor in series with the relay coil.

Input power to the dc regulators is a 137V (rms), 2.5-kHz square wave from the C/I. The 137V square wave is supplied to the regulators via four cables from the C/I. Jack



●Figure 4-8. SE AC Distribution and Controls



● Figure 4-9. Storage Element DC Regulators and Controls

J2 supplies the regulators in the SSU power tub. Jacks J3, J4 and J5 feed the regulators in the three storage section power tubs.

The C/I also supplies +25V bias to all regulators. TB1 in the C/I is the output terminal block for the +25V bias. Relay K29 senses the presence of bias voltage, and its points are used by the power-on and the power-off sequences.

The regulators are sequenced on in two groups. SSU and storage +3V, -3V, +6V, and +6V(M) regulators are energized as soon as output from the C/I is available. Relay K51 is energized by sequencing control circuitry to bring up the HV supplies.

SSU interface driver voltage regulator A3 is under control of relay A2K1. When the TEST/NORMAL switch is set to TEST and the SE is in state zero, relay A2K1 drops, thereby removing +6M from the SSU circuitry.

SSU Regulators

The SSU uses six dc regulators. Table 4-1 lists the six regulators and gives additional information about current ratings and logic locations. Each regulator has a sense relay which is used by the power-on and power-off sequences. The sense relay is energized when the regulator delivers its output voltage, and remains energized as long as the regulator continues to provide the output voltage. The sense relays are mounted under the SSU power control panel.

Temperature in the power supply tub is monitored by two thermal switches located above the regulators. The 130°F thermal switch lights the THERMAL WARNING indicator (DS7) on the storage power control panel. The 140°F thermal switch picks SSU relay K3 and lights MODULE THERMAL indicator (DS9) when that temperature is exceeded.

Table 4-1. SSU Section Regulator Data

Regulator	Nominal Voltage	Ampere Rating	Logic Location	Logic Reference	Sense Relay
A1	+3	40	YC020	YF035	K11
A2	+3	40	YC020	YF035	K6
A3	+6 (M)	40	YC020	YF036	K10
B1	-3	20	YC020	YF279	K8
B2	+3	40	YC020	YF035	K9
B3	+6 (M)	40	YC020	YF036	K7

Storage Regulators

The storage section uses 22 dc regulators. Table 4-2 lists the 22 regulators and gives additional information about current ratings and logic locations. The regulators are mounted in three power supply tubs in frame 5 of the SE. The inner, rigidly mounted power tub contains regulators 1–11. The swinging power tub contains regulators 12–18. Regulators 19–22 are housed in the power tub at the rear of frame 5.

Special voltages required for the storage protect circuitry (SP4) are developed by dc regulators 12 (+6K) and 13 (+6TC). These two storage-protect sink supplies are powered by the +18V output of dc regulator 8.

The three power tubs are temperature-protected by two thermal sensing switches located at the top of each tub. A thermal warning is indicated when one of the three 130°F thermal switches opens. A power-down sequence begins when one of the three 140°F thermal switches opens.

Table 4-2. Storage Section Regulator Data

Regulator	Nominal Voltage	Ampere Rating	Logic Location	Logic Reference	Sense Relay
1	+6	40	YD060	YF034	K15
2	- 3	40	YD060	YF035	K16
3	+3	40	YD070	YF035	K17
4	+3	40	YD070	YF035	K18
5	+3	40	YD070	YF035	K19
6	+6 (M)	47	YD060	YF036	K20
7	+6	40	YD060	YF034	K21
8	+18	10	YD080	YF025	None
9	+30	5	YD090	YF280	K25
10	+6	40	YD060	YF034	K22
11	+6	40	YD060	YF034	K23
*12	+6(K)	1	YD080	YF375	K26
*13	+6 (TC)	1	YD080	YF375	K27
14	- 23	40	YD090	YF026	K28
15	- 23	40	YD080	YF026	K31
16	- 18	6.5	YD080	YF025	K32
17	+30	12	YD080	YF377	K33
18	+30	12	YD070	YF377	K34
19	- 18	6.5	YD090	YF025	K35
20	+30	12	YD090	YF377	K36
21	+3	20	YD070	YF279	K24
22	+30	12	YD090	YF377	K37

*PS 12 and PS 13 comprise the +6V sink supply.

Power-On Sequence

- Automatic power-on sequence when prime power is applied.
- Adjustable time delay relay staggers system power on.
- Low-voltage (LV) supplies power-up first.
- High-voltage supplies power-up when all LV supplies are energized.

The SE performs an automatic power-on sequence as soon as primary power is applied and the PWR ON/OFF/RESET

switch on the storage power control panel is on. The sequence is under control of time delay relay K45 (start delay) which is adjustable from 0.6 to 60 seconds of delay. Each element in the system contains a similar relay. The relays are adjusted to stagger the times at which the various elements power-up.

The SE power sequence and control circuits are shown in Figure 4-10. Figure 4-11 shows the power-on sequence. (Logic page YD010 presents the power-on sequence in timing chart form.)

Low-Voltage Sequencing

The power-on sequence begins when the SE is connected to primary power and mainline circuit breaker CB 1 is turned on. Input voltage is applied to the prime power supply which provides +24V dc output. The 24V prime power supply also provides 28V ac to the C/I. The C/I rectifies this 28V ac to produce the +25V dc bias used by the dc regulators. Storage thermal relays K5, K6, K10 through K14, K38, K43, and SSU relays K3 and K4 are energized from the +24V dc bus through the N/C point of relay K1. The thermal relays hold through their own N/O points and their associated N/C thermal switches.

The PWR ON switch on the storage power control panel is turned on to continue the power-on sequence. Adjustable start delay relay K45 picks through the PWR ON switch. Relay K45 is adjustable from 5 to 30 seconds of delay before the points transfer. K2 (start sequence) picks after waiting the preset delay time for K45 to transfer. K4 (C/I start) picks through the N/O K2 points.

The 208V ac power-on contactors K41 and K42 pick in parallel through the N/O K4 points. 208V ac is provided to the input of the C/I, the line sense and battery charger circuitry, storage fans, storage heaters, SSU power fan, and the gate blowers through the N/O points of K41 and K42. Relay K40 (line sense) picks through a K41 N/O point and stays energized as long as 208V ac line voltage is present. The C/I output is applied to the storage and SSU dc regulators. The outputs of the storage regulators pick their associated sense relays K15–K24. When the SSU regulators deliver output voltage, their corresponding SSU sense relays K6–K9 and K11 pick. Regulator sense relays remain energized as long as there is output voltage from the regulator. As soon as storage sense relay K22 or K23 transfers, relays K52 and K54 in the line sense and switching circuit pick in parallel. Relays K52 and K54 are held picked during normal power-on conditions. SSU relay K2 picks, and the DC ON (L4 on the SSU power panel) indicator lights through the N/O point of the +3V, -3V, and +6V sense relays connected in series.

High-Voltage Sequencing

Since the +3V, -3V, and +6V logic supplies are now energized, K8 (bootstrap transfer) and K51 (start HV power supply input) relays pick through the N/O point of SSU relay K2. The remaining +30V, +18V, -18V, and -23V storage regulators are energized through the N/O points of K51. When the storage HV regulators come up, they pick the HV sense relays K25–K28 and K31–K37. The remaining SSU regulator A3 is gated through the N/O points of A2K1 if the TEST/NORMAL switch is in NORMAL, and all other regulators are energized.

SSU DRVR ON indicator L2 lights through a K10 N/O point. Another K10 N/O point picks relays K3 (power check) and K7 (sequence complete). The power-on sequence is completed when the POWER CHECK indicator is extinguished by K12 N/C point opening. Relay K53 drops through a now opened K7 N/C point, and PWR COMPLETE indicator DS 1 comes on.

Normal Power-Off Sequence

- TEST/NORMAL switch must be in TEST.
- PWR ON/OFF/RESET switch in OFF initiates power-off sequence.
- Battery backup supply is deactivated.
- Sequence down is performed in two steps: HV regulators drop first; LV regulators drop when all HV regulators are de-energized.
- Certain control relays remain energized when power-off sequence is completed.

Normal power-off, under control of the PWR ON/OFF/RESET switch is shown in Figure 4-12. The SE power sequence and control circuits are shown in Figure 4-10.

Normal power-off can be performed only when the SE is in state zero and the TEST/NORMAL switch is in TEST. SSU relay K1 (test/normal) picks under control of the 'test mode' signal generated by the TEST/NORMAL switch located on the maintenance panel. SSU relay A2K1 (gate +6V driver) drops when its hold circuit is broken by energizing SSU relay K1. With relay A2K1 de-energized, the

output voltage of regulator A3 and its associated sense relay (SSU K10) drops. Because relay K7 (sequence complete) is held through an N/O K10 point, it drops when the K10 points open. However, the SEQUENCE COMPLETE indicator remains lit since SSU relay K2 (dc on) is still energized and one of its N/O points completes the circuit to keep the indicator lit.

The SE is now in a condition to power-down under control of the PWR ON/OFF/RESET switch, located on the storage power control panel. Storage relay K2 (start sequence) is energized when the PWR ON switch is in its normal (PWR ON) position. When the switch is turned to OFF, relay K2 drops. Storage relay K53 (arm/disarm line sense), located in the line sense and switching circuit, picks through a now closed K2 point. When K53 is energized, the battery backup pack is deactivated. SSU relay K2 (dc on) drops, and DC ON indicator L4 is extinguished. Storage relay K3 (power check) drops, and SEQUENCE COMPLETE indicator DS1 is extinguished since they both are held energized by a K2 N/O point. Storage relay K51 (start HV power supply input) drops when its parallel hold circuit (consisting of SSU relays K2 N/O and K10 N/O) is opened.

Input to the HV power supplies is under control of the N/O points of K51. When K51 drops, the N/O points open, and the input to the regulators is interrupted. Power supply regulators 8, 9, 12–20, and 22 cease to provide output voltages, and their associated sense relays, K25–K28 and K31–K37, drop. When all HV regulator sense relays are down, storage relay K4 (C/I start) drops. In the line sense and switching circuit, relay K52 (charger control) and contactor K54 (charger contactor) drop since their hold circuit was through HV sense relays K25 N/O and K26 N/O, both of which are down.

Power-on contactors K41 and K42 drop in parallel when K4 N/O opens their hold circuits. With the power-on contactors down, the 208V ac, 3-phase input to the C/I is removed. Relay K40 (line sense) drops because its hold circuit is through a K41 N/O point. 208V ac is also removed from all heaters and fans when contactors K41 and K42 open their N/O points.

The remaining storage and SSU power supplies cease to provide output voltages because the C/I no longer provides 2.5-kHz square-wave input to the regulators. The LV regulators that drop are: SSU regulators A1, A2, and B1 through B3, and storage regulators 1–7, 10, 11, and 21. As the output voltage from each regulator drops, the associated sense relay for that regulator also drops. The associated sense relays are SSU K5–K9, and K11 and storage relays K15–K24.

The normal power-off sequence is completed. Thermal relays and relays K53 and K8 remain energized until 208V ac input voltage is removed from the SE by opening mainline circuit breaker CB1, or until a power fault occurs during normal operation.

Battery Backup Power Control

- Uninterrupted battery backup for 5.5 seconds following power loss.
- Loss of primary power is sensed as a decay of converter dc output within the C/I.
- Battery backup power is not applied under EPO/MPO conditions.

The SE has a battery backup power source that permits uninterrupted power for 5.5 ± 0.5 seconds following the loss of 208V ac primary input power.

Loss of primary input power is detected as a voltage decay on the dc bus between the converter and inverter sections of the C/I. When this voltage drops below a preset limit (about +240V dc), a preconditioned silicon-controlled rectifier (SCR) in the line sense and switching circuit conducts and feeds battery power to the input of the inverter section in the C/I, thus allowing the C/I to continue providing uninterrupted input to the dc regulators.

Under conditions where prime power is not restored within 5.5 seconds, the SE begins a power-off sequence.

Figure 4-13 shows the SE battery backup operation when prime power is restored within 5.5 seconds after loss, and when prime power is not restored within 5.5 seconds. The power-off sequence that results in the latter case is also described.

Battery Backup with Prime Power Restored

- Battery backup supply is switched in automatically.
- Battery supply is active for 5.5 seconds.

Loss of 208V ac input power is sensed by the line sense and switching circuitry. An SCR (silicon-controlled rectifier) in that circuit switches the battery supply output to the input of the inverter circuit. Since there is no longer any ac input voltage to the SE, the 24V prime power supply output drops, mainline contactors K41 and K42 and line sense relay K40 drop, and the fans and heaters stop. Through the N/O reed relay point in the line sense circuitry, relays K39 (battery on) and K44 (sense OBS) pick. The K39 points turn on the BTRY ON indicator (DS 5 on the storage power control panel) and the BATTERY indicator on the system or configuration console operator's panel. An OBS (on-battery supply) signal is also sent to the SE logic

circuitry through N/O K44 points. Switching to battery power also starts the 5.5-second delayed-pick relay K46 (OBS 5 second delay) timing out.

If mainline 208V ac power is restored before K46 picks, the SE remains in a power-on condition. If relay K46 picks before mainline power is restored, a power-off sequence is begun. The power-off sequence is described in later paragraphs.

The 24V prime power supply is energized as soon as the 208V ac input voltage is restored. Power-on contactors K41 and K42 pick since there is now an output voltage from the 24V prime power supply. The fans and heaters resume operation, and K40 (line sense) picks through the K41 points.

Battery power is used until the 5.5-second delay of K46 expires even though mainline power is restored. When the K46 points transfer, relay K52 (charger control) and contactor K54 (charger contactor) in the line sense and switching circuit drop because the hold circuit through the N/C K46 points no longer exists. The K54 N/C points reapply potential to the anode of the switching SCR, enabling it to conduct on the next demand from the sensing circuit. K54 N/O points also remove the battery supply output from the C/I.

Relays K39 and K44 drop in parallel under control of the reed relay in the line sense circuit. Because K46 and the BTRY ON indicator are energized through K39 N/O, relay K46 drops and the BTRY ON indicator goes out. Relay K52 and contactor K54 pick through K46 N/C.

The SE is again operating from prime power, the line sense and switching circuit is re-established, and the battery backup package is ready for another emergency.

Battery Backup without Prime Power Restored

- 5.5 seconds on-battery backup.
- Begin power-off sequence after 5.5 seconds.
- Power can automatically sequence on when prime power input returns.

When the SCR switches battery power into the SE, reed relay 1 (RR1) picks in the line sense and switching circuit and provides a pick circuit for relays K39 (battery on) and K44 (sense OBS). As previously described, the K39 points turn on the BTRY ON indicator on the SE power control panel and provide an OBS (on-battery supply) signal to SE logic circuitry.

If at the end of the 5.5-second delay prime power is not restored, relay K46 points transfer and the power-off sequence begins. K46 N/C opens the hold circuit for storage relay K2 (start sequence). K2 N/O points drop SSU relay K2 (dc on) SSU relay A2K1 (start +6V driver), and extinguish the DC ON indicator on the SSU power control panel. SSU relay K10, the sense relay for regulator A3, drops when the regulator output voltage drops. K10 N/O points open the hold circuit for storage relays K3 (power check) and K7 (sequence complete). The PWR COMPLETE indicator is extinguished in parallel with K7 dropping. The hold circuit for relay K51 (start HV power supply input) is open since both K2 and K10 are down.

Input to the storage HV regulators is removed when the K51 N/O points open. Because 2.5-kHz input from the C/I is no longer delivered to the regulators, the regulator outputs decay, and the associated sense relays (K25–K28 and K31–K37) drop. K4 (C/I start) drops when all of the HV sense relays open. The K4 N/O points drop K52 and K54 in the line sense and switching circuit.

Contactor K54 opens the SCR anode circuit which supplies battery power to the C/I. Without 2.5-kHz C/I output, the last dc voltage group (+3V, -3V, and +6V logic supplies) and the bootstrap power supply turn off. Relays K39 and K44 also drop since holding voltage is no longer available.

At the completion of the power-off sequence, all relays are de-energized and all indicators are extinguished. However, since the PWR ON/OFF/RESET switch is in PWR ON, power is automatically sequenced up when primary power is restored.

Emergency Power-Off Sequence

- EPO and MPO conditions immediately remove all power, except 24V prime power supply.
- Normal power-off sequencing is bypassed.
- Battery backup is prevented under EPO/MPO conditions.

If either the system EPO or the element MPO switch is pulled, all power is turned off in the SE except the +24V dc and 28V ac control voltages provided by the 24V prime power supply. The EPO and MPO switch are mechanical latch types that must be reset manually. Pulling the MPO switch has no effect on system power, but pulling the system EPO switch removes power from all attached elements.

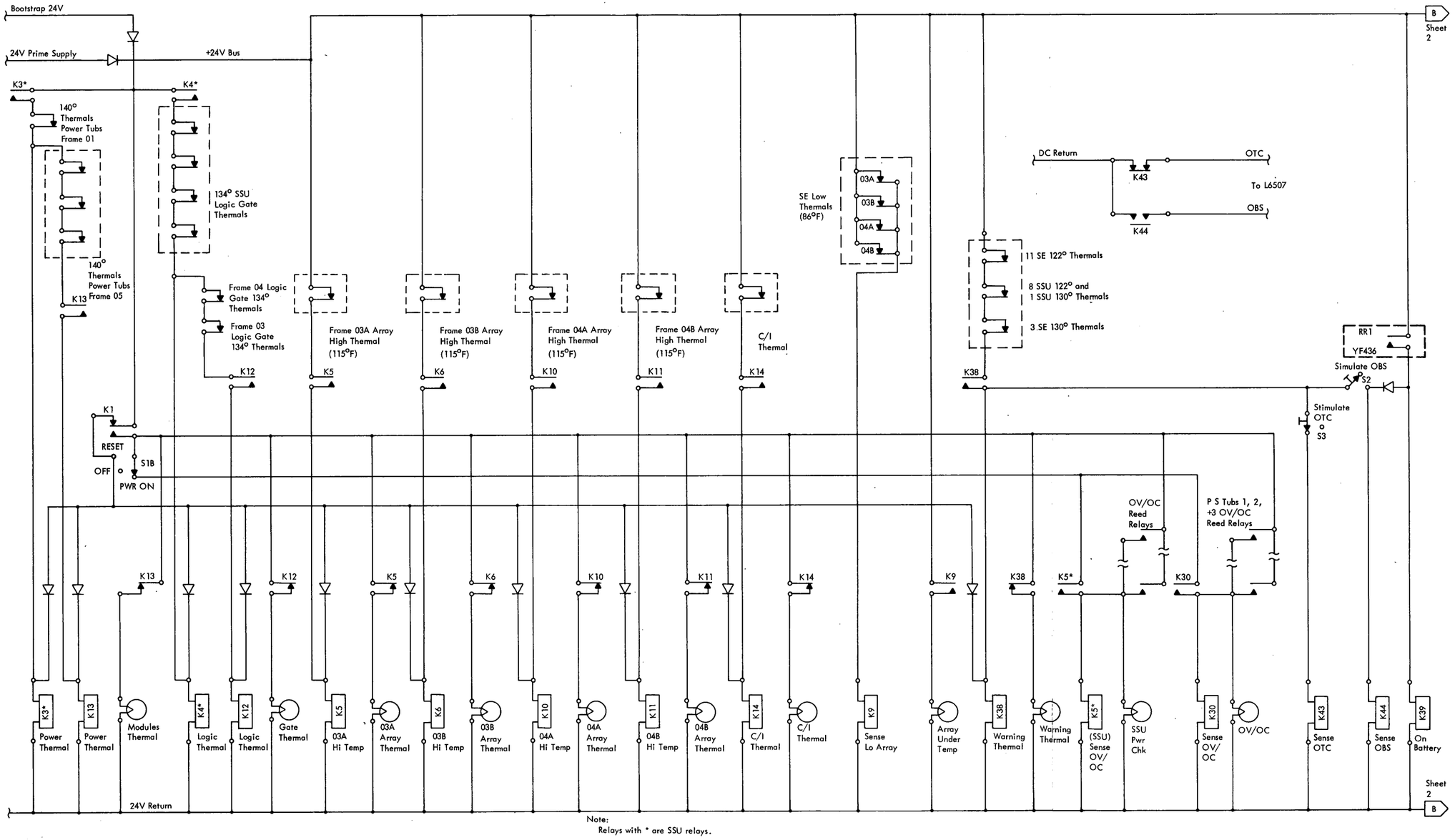
Refer to Figures 4-7 and 4-10. Pulling either the EPO switch or the MPO switch drops storage relay K1 (EPO control). The dropping of K1 drops the +24V dc bus that holds storage relays K2, K3, K4, K7, K8, and K51 and SSU relays K2 and A2K1. Relay K53 (arm/disarm line sense), located in the sense and switching circuit, picks through

Storage Relays

K1	EPO Control
K2	Start Sequence
K3	Power Check
K4	C/I Start
K5	03A High Temperature
K6	03B High Temperature
K7	Sequence Complete
K8	Bootstrap Transfer
K9	Sense Low Array Thermal
K10	04A High Temperature
K11	04B High Temperature
K12	Logic Thermal
K13	Power Thermal
K14	C/I Thermal
K22	+6V Sense (PS10)
K23	2 Second Delay
K25	+30V Sense (PS9)
K26	+6V Sense (PS12)
K30	Sense OV/OC
K38	Warning Thermal
K39	On Battery
K40	Line Sense
K43	Sense OTC
K44	Sense OBS
K45	Start Delay
K46	OBS 5-Second Delay
K47	Convenience Outlet Control
K51	Start 4V P S
K52	Charger Contactor
K53	Arm/Disarm Line Sense
K54	Charger Contactor

SSU Relays

K1	Test/Normal
K2	DC On
K3	Power Thermal
K4	Logic Thermal
K5	Sense OV/OC



Note:
Relays with * are SSU relays.

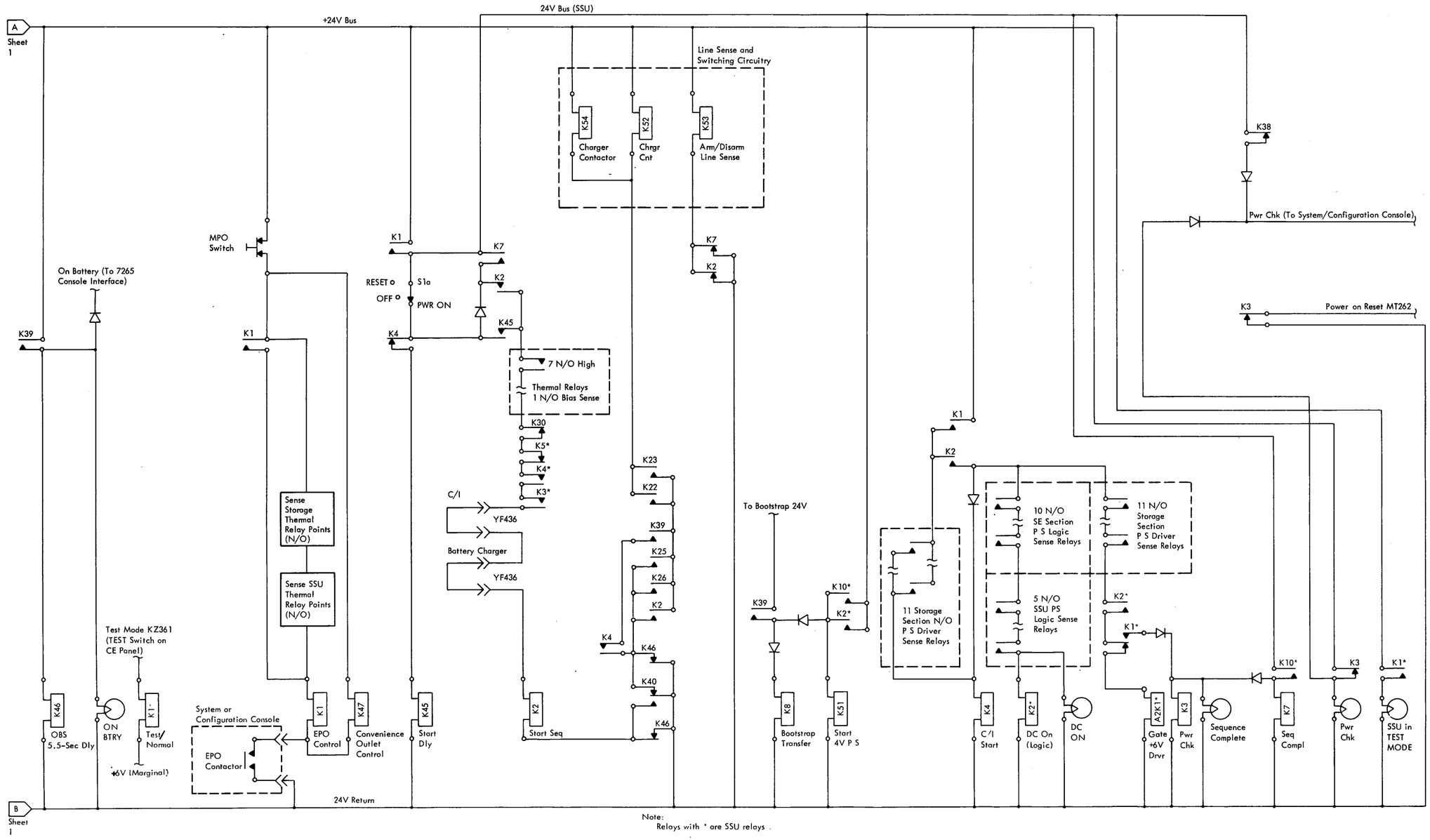
●Figure 4-10. SE Power Sequence and Control Circuitry (Sheet 1 of 2)

Storage Relays

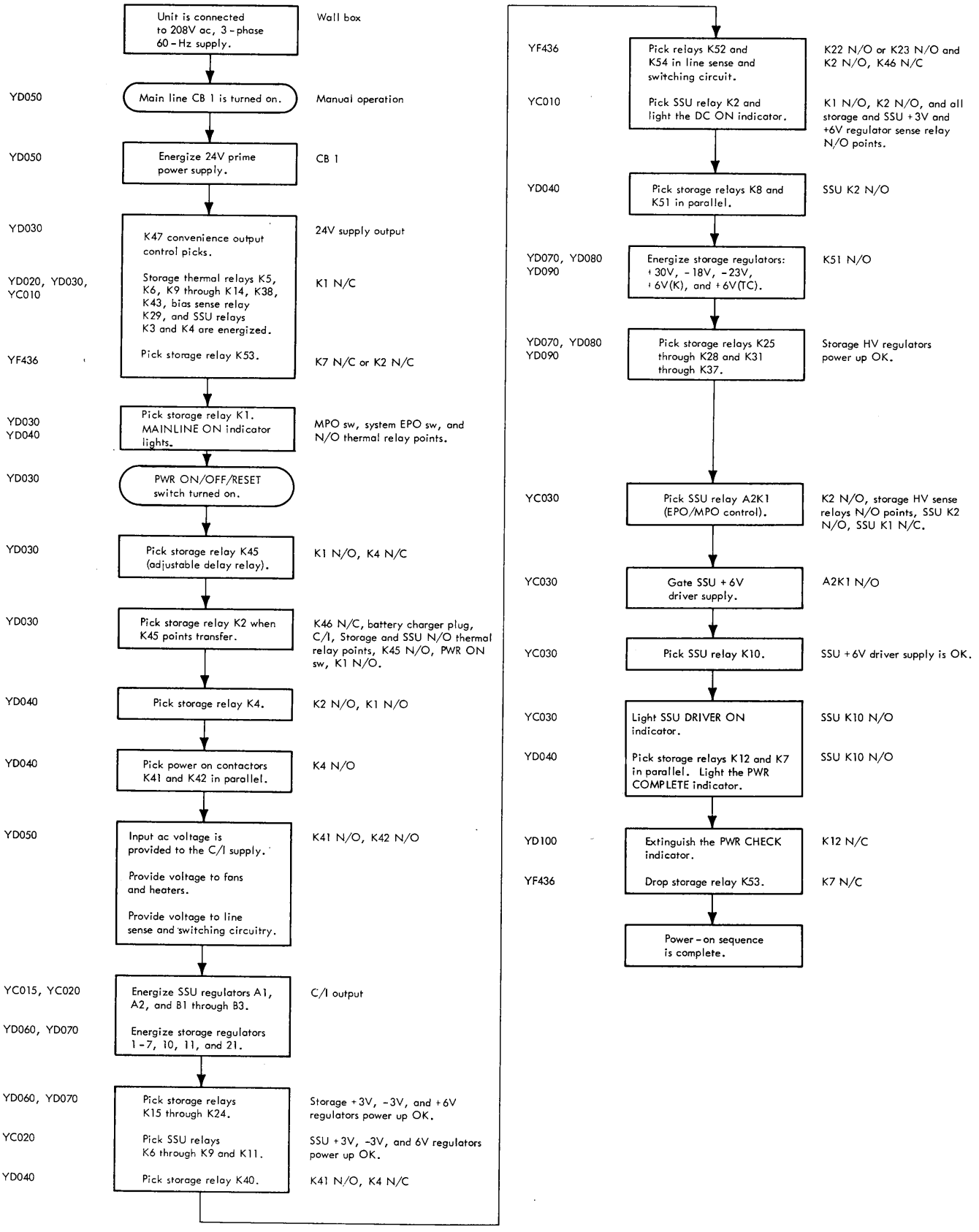
K1 EPO Control
K2 Start Sequence
K3 Power Check
K4 C/I Start
K5 03A High Temperature
K6 03B High Temperature
K7 Sequence Complete
K8 Bootstrap Transfer
K9 Sense Low Array Thermal
K10 04A High Temperature
K11 04B High Temperature
K12 Logic Thermal
K13 Power Thermal
K14 C/I Thermal
K22 +6V Sense (PS10)
K23 2 Second Delay
K25 +30V Sense (PS9)
K26 +6V Sense (PS12)
K30 Sense OV/OC
K38 Warning Thermal
K39 On Battery
K40 Line Sense
K43 Sense OTC
K44 Sense OBS
K45 Start Delay
K46 OBS 5-Second Delay
K47 Convenience Outlet Control
K51 Start 4V P S
K52 Charger Contactor
K53 Arm/Disarm Line Sense
K54 Charger Contactor

SSU Relays

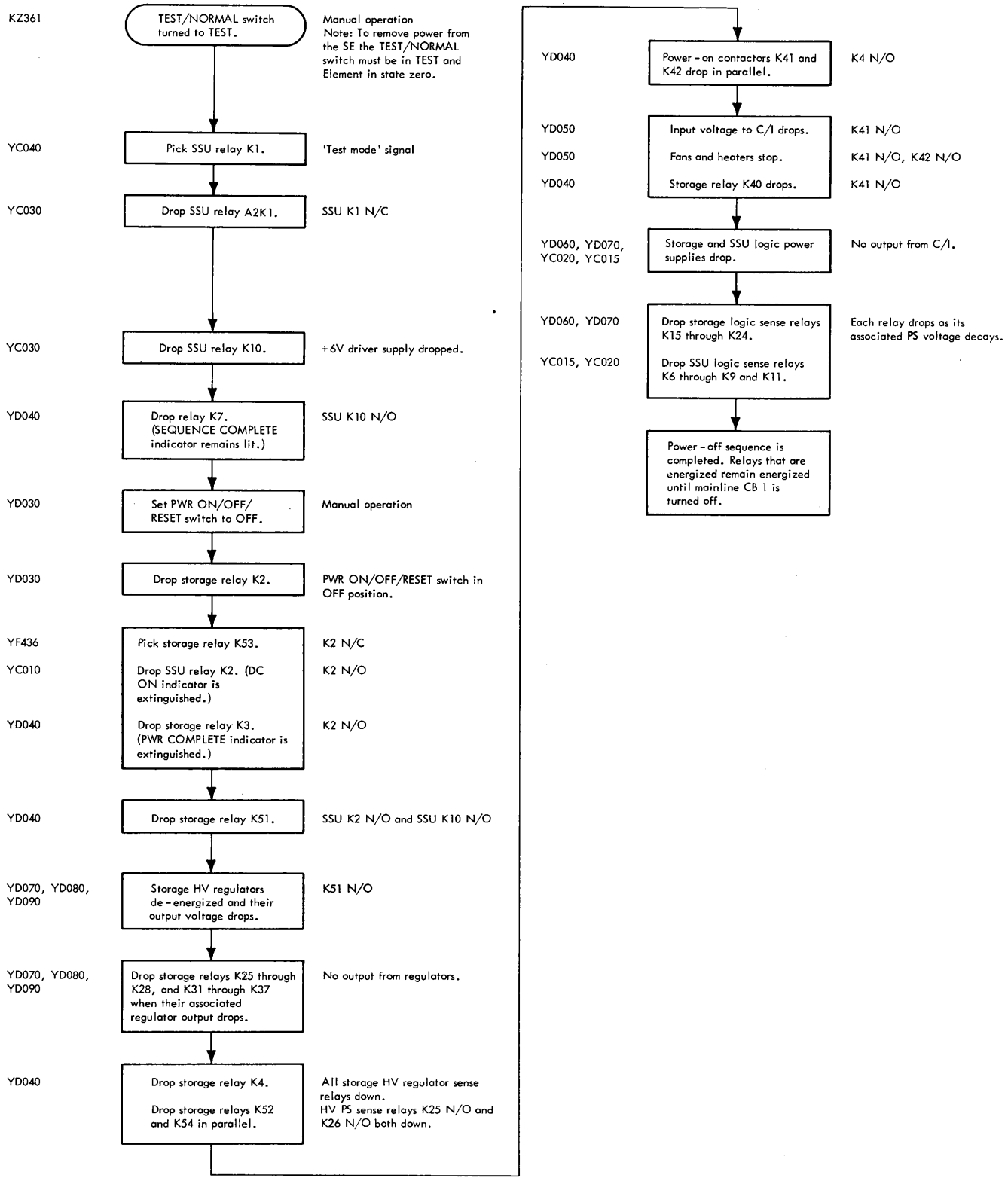
K1 Test/Normal
K2 DC On
K3 Power Thermal
K4 Logic Thermal
K5 Sense OV/OC



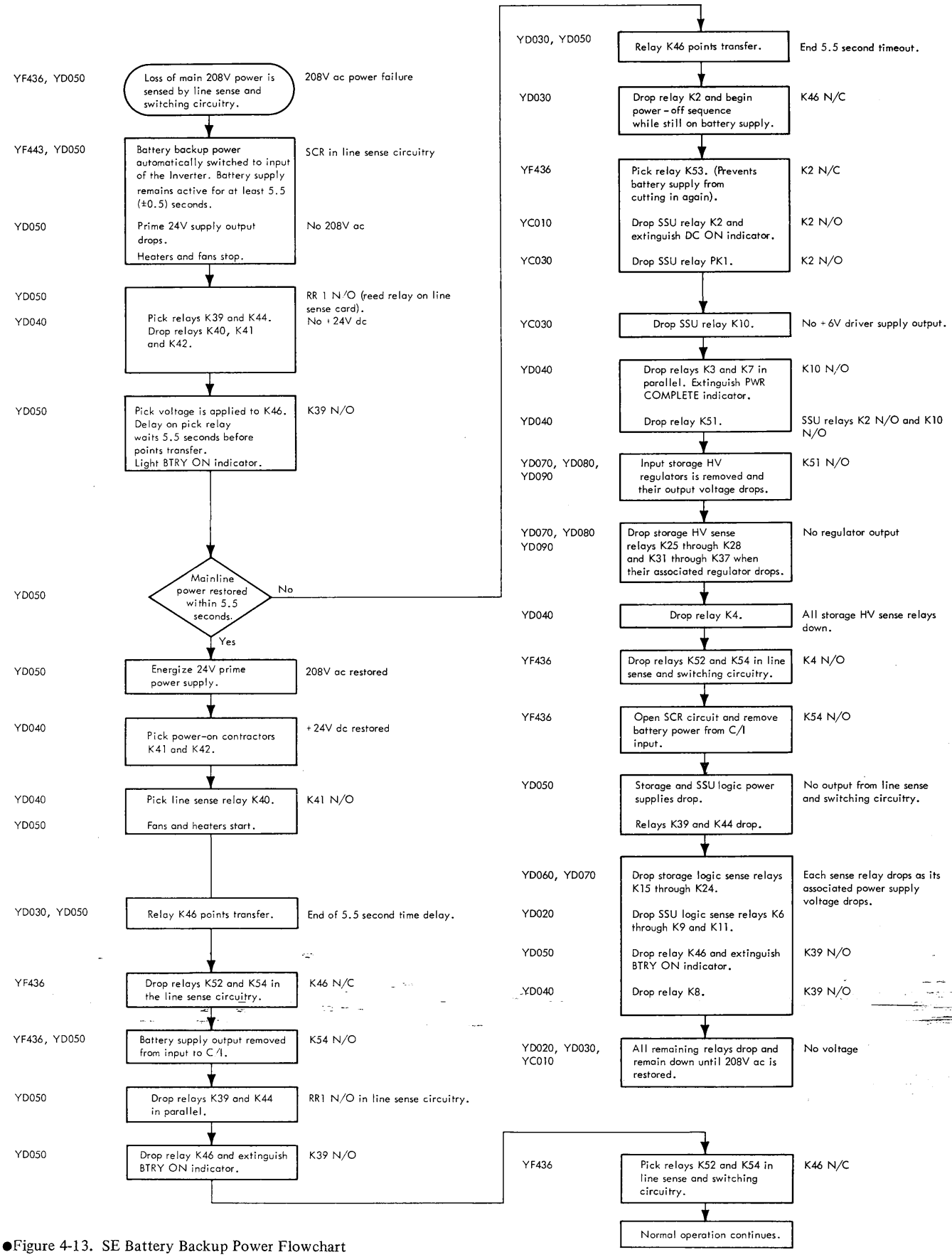
●Figure 4-10. SE Power Sequence and Control Circuitry (Sheet 2 of 2)


Unit is connected to 208V ac, 3-phase 60-Hz supply.
Wall box
YD050
Main line CB 1 is turned on.
Manual operation
YD050
Energize 24V prime power supply.
CB 1
YD030
K47 convenience output control picks.
24V supply output
YD020, YD030, YC010
Storage thermal relays K5, K6, K9 through K14, K38, K43, bias sense relay K29, and SSU relays K3 and K4 are energized.
K1 N/C
YF436
Pick storage relay K53.
K7 N/C or K2 N/C
YD030 YD040
Pick storage relay K1. MAINLINE ON indicator lights.
MPO sw, system EPO sw, and N/O thermal relay points.
YD030
PWR ON/OFF/RESET switch turned on.
YD030
Pick storage relay K45 (adjustable delay relay).
K1 N/O, K4 N/C
YD030
Pick storage relay K2 when K45 points transfer.
K46 N/C, battery charger plug, C/I, Storage and SSU N/O thermal relay points, K45 N/O, PWR ON sw, K1 N/O.
YD040
Pick storage relay K4.
K2 N/O, K1 N/O
YD040
Pick power on contactors K41 and K42 in parallel.
K4 N/O
YD050
Input ac voltage is provided to the C/I supply.
Provide voltage to fans and heaters.
Provide voltage to line sense and switching circuitry.
K41 N/O, K42 N/O
YC015, YC020
YD060, YD070
Energize SSU regulators A1, A2, and B1 through B3.
Energize storage regulators 1-7, 10, 11, and 21.
C/I output
YD060, YD070
YC020
YD040
Pick storage relays K15 through K24.
Pick SSU relays K6 through K9 and K11.
Pick storage relay K40.
Storage +3V, -3V, and +6V regulators power up OK.
SSU +3V, -3V, and 6V regulators power up OK.
K41 N/O, K4 N/C
YF436
Pick relays K52 and K54 in line sense and switching circuit.
K22 N/O or K23 N/O and K2 N/O, K46 N/C
YC010
Pick SSU relay K2 and light the DC ON indicator.
K1 N/O, K2 N/O, and all storage and SSU +3V and +6V regulator sense relay N/O points.
YD040
Pick storage relays K8 and K51 in parallel.
SSU K2 N/O
YD070, YD080 YD090
Energize storage regulators: +30V, -18V, -23V, +6V(K), and +6V(TC).
K51 N/O
YD070, YD080 YD090
Pick storage relays K25 through K28 and K31 through K37.
Storage HV regulators power up OK.
YC030
Pick SSU relay A2K1 (EPO/MPO control).
K2 N/O, storage HV sense relays N/O points, SSU K2 N/O, SSU K1 N/C.
YC030
Gate SSU +6V driver supply.
A2K1 N/O
YC030
Pick SSU relay K10.
SSU +6V driver supply is OK.
YC030
YD040
Light SSU DRIVER ON indicator.
Pick storage relays K12 and K7 in parallel. Light the PWR COMPLETE indicator.
SSU K10 N/O
SSU K10 N/O
YD100
YF436
Extinguish the PWR CHECK indicator.
Drop storage relay K53.
K12 N/C
K7 N/C
Power-on sequence is complete.

●Figure 4-11. SE Power-On Flowchart


KZ361
TEST/NORMAL switch turned to TEST.
Manual operation
Note: To remove power from the SE the TEST/NORMAL switch must be in TEST and Element in state zero.
YC040
Pick SSU relay K1.
'Test mode' signal
YC030
Drop SSU relay A2K1.
SSU K1 N/C
YC030
Drop SSU relay K10.
+6V driver supply dropped.
YD040
Drop relay K7. (SEQUENCE COMPLETE indicator remains lit.)
SSU K10 N/O
YD030
Set PWR ON/OFF/ RESET switch to OFF.
Manual operation
YD030
Drop storage relay K2.
PWR ON/OFF/RESET switch in OFF position.
YF436
Pick storage relay K53.
K2 N/C
YC010
Drop SSU relay K2. (DC ON indicator is extinguished.)
K2 N/O
YD040
Drop storage relay K3. (PWR COMPLETE indicator is extinguished.)
K2 N/O
YD040
Drop storage relay K51.
SSU K2 N/O and SSU K10 N/O
YD070, YD080, YD090
Storage HV regulators de-energized and their output voltage drops.
K51 N/O
YD070, YD080, YD090
Drop storage relays K25 through K28, and K31 through K37 when their associated regulator output drops.
No output from regulators.
YD040
Drop storage relay K4.
Drop storage relays K52 and K54 in parallel.
All storage HV regulator sense relays down.
HV PS sense relays K25 N/O and K26 N/O both down.
YD040
Power-on contactors K41 and K42 drop in parallel.
K4 N/O
YD050
Input voltage to C/I drops.
K41 N/O
YD050
Fans and heaters stop.
K41 N/O, K42 N/O
YD040
Storage relay K40 drops.
K41 N/O
YD060, YD070, YC020, YC015
Storage and SSU logic power supplies drop.
No output from C/I.
YD060, YD070
Drop storage logic sense relays K15 through K24.
YC015, YC020
Drop SSU logic sense relays K6 through K9 and K11.
Each relay drops as its associated PS voltage decays.
Power-off sequence is completed. Relays that are energized remain energized until mainline CB 1 is turned off.

●Figure 4-12. SE Power-Off Flowchart


YF436, YD050
Loss of main 208V power is sensed by line sense and switching circuitry.
208V ac power failure
YF443, YD050
Battery backup power automatically switched to input of the Inverter. Battery supply remains active for at least 5.5 (±0.5) seconds.
SCR in line sense circuitry
YD050
Prime 24V supply output drops.
Heaters and fans stop.
No 208V ac
YD050
YD040
Pick relays K39 and K44.
Drop relays K40, K41 and K42.
RR 1 N/O (reed relay on line sense card).
No +24V dc
YD050
Pick voltage is applied to K46.
Delay on pick relay waits 5.5 seconds before points transfer.
Light BTRY ON indicator.
K39 N/O
YD050
Mainline power restored within 5.5 seconds.
No
Yes
YD050
Energize 24V prime power supply.
208V ac restored
YD040
Pick power-on contractors K41 and K42.
+24V dc restored
YD040
YD050
Pick line sense relay K40.
Fans and heaters start.
K41 N/O
YD030, YD050
Relay K46 points transfer.
End of 5.5 second time delay.
YF436
Drop relays K52 and K54 in the line sense circuitry.
K46 N/C
YF436, YD050
Battery supply output removed from input to C/I.
K54 N/O
YD050
Drop relays K39 and K44 in parallel.
RR1 N/O in line sense circuitry.
YD050
Drop relay K46 and extinguish BTRY ON indicator.
K39 N/O
YD030, YD050
Relay K46 points transfer.
End 5.5 second timeout.
YD030
Drop relay K2 and begin power-off sequence while still on battery supply.
K46 N/C
YF436
Pick relay K53. (Prevents battery supply from cutting in again).
K2 N/C
YC010
Drop SSU relay K2 and extinguish DC ON indicator.
K2 N/O
YC030
Drop SSU relay PK1.
K2 N/O
YC030
Drop SSU relay K10.
No +6V driver supply output.
YD040
Drop relays K3 and K7 in parallel. Extinguish PWR COMPLETE indicator.
K10 N/O
YD040
Drop relay K51.
SSU relays K2 N/O and K10 N/O
YD070, YD080, YD090
Input storage HV regulators is removed and their output voltage drops.
K51 N/O
YD070, YD080 YD090
Drop storage HV sense relays K25 through K28 and K31 through K37 when their associated regulator drops.
No regulator output
YD040
Drop relay K4.
All storage HV sense relays down.
YF436
Drop relays K52 and K54 in line sense and switching circuitry.
K4 N/O
YF436
Open SCR circuit and remove battery power from C/I input.
K54 N/O
YD050
Storage and SSU logic power supplies drop.
Relays K39 and K44 drop.
No output from line sense and switching circuitry.
YD060, YD070
Drop storage logic sense relays K15 through K24.
Each sense relay drops as its associated power supply voltage drops.
YD020
Drop SSU logic sense relays K6 through K9 and K11.
YD050
Drop relay K46 and extinguish BTRY ON indicator.
K39 N/O
YD040
Drop relay K8.
K39 N/O
YD020, YD030, YC010
All remaining relays drop and remain down until 208V ac is restored.
No voltage
YF436
Pick relays K52 and K54 in line sense and switching circuitry.
K46 N/C
Normal operation continues.

●Figure 4-13. SE Battery Backup Power Flowchart

normally closed K2 and K7 points. When K53 picks, it prevents the battery backup supply from cutting in. Power-on contactors K41 and K42 drop because their hold circuit through the N/O K4 points is broken as a result of K4 having dropped. Fans, blowers, and heaters stop under control of K41 and K42.

All storage HV regulators drop because K51 interrupted the square-wave input from the C/I. Their associated sense relays drop when the regulators cease to provide output voltage. The output of SSU regulator A3 is degated when A2K1 drops. Its sense relay (SSU K10) drops when the regulator output voltage decays. Since the power-on contactors are down, storage relay K40 (line sense) also drops.

EPO/MPO power-off sequencing continues when all remaining storage and SSU regulators drop. All the storage and SSU LV sense relays drop when the LV regulators stop providing output voltage. Relay K52 (charger control) and contactor K54 (charger contactor), both located in the line sense and switching circuitry, drop in parallel.

When the EPO/MPO power-off sequencing is completed, the 24V prime power supply still provides +24V dc and 28V ac. Therefore, certain control relays remain energized. Since the EPO and the MPO switches contain mechanical interlocks, automatic power sequencing cannot begin until the switch that was pulled is reset by maintenance personnel.

CAUTION

When EPO/MPO is reset, the element will sequence back on if the PWR/ON/OFF/RESET switch is in PWR ON and SE protective circuitry (OV/OC, thermal, etc.) has not been activated prior to pulling the MPO or EPO switch.

Special Power-Off Sequences

Two categories of special power-off sequences are described in the following text. These sequences result from the detection of OV/OC condition of a dc regulator or an overtemperature (thermal) condition in the SE.

Overvoltage/Overcurrent Power-Off Sequence

- Each regulator has an OV/OC sense circuit.
- An OV/OC condition automatically sequences power off.
- Power does not sequence up until OV/OC condition is reset.
- Battery backup is prevented under OV/OC condition.

Each storage and SSU regulator in the SE has an OV/OC sense circuit. If an OV/OC condition occurs in a regulator, its respective sense circuit picks a reed relay located on an OV/OC SMS card internal to the supply. The N/O contacts of any sense relay that detects an OV/OC condition pick either storage relay K30 (sense OV/OC) or SSU relay K5 (sense OV/OC), and light the OV/OC indicators (DS3) and (L3) respectively. K30 holds through its own N/O point. The N/C K30 points break the hold circuit for storage relay K2 (start sequence). In the line sense and switching circuit, K53 (arm/disarm line sense) picks to prevent the battery backup supply from cutting in. The SE begins a power-off sequence similar to the "Normal Power-Off Sequence" described earlier. The description below assumes that an OV/OC condition occurs in a storage power regulator. An SSU OV/OC condition results in the same power-off sequence, except that SSU relay K5 serves the same function as storage relay K30 in sensing the OV/OC condition and breaking the hold circuit to K2 (start sequence). The timing chart on logic page YD010 shows the power-off sequence in detail.

During the power-off sequence, K30 remains energized through the pick circuit (the N/O reed relay point) and through a hold circuit established by the N/O K30 point in series with the PWR ON/OFF/RESET switch. To restore power to the SE, the OV/OC condition must be reset manually at the C/I, and the PWR ON/OFF/RESET switch must be turned to RESET, then to PWR ON.

Pressing RESET at the C/I drops the OV/OC reed relay at the regulator. The reed relay N/O point opens the pick circuit for K30. K30 continues to hold through the PWR ON/OFF/RESET switch. When this switch is turned to RESET, K30 drops. The N/C K30 point re-establishes the pick circuit for storage relay K2 (sequence start) so a normal power-on sequence (described earlier) can begin when the PWR ON/OFF/RESET switch is returned to PWR ON.

If the OV/OC condition is not reset before the PWR ON/OFF/RESET switch is activated, K30 will continue to hold through the N/O reed relay point. With K30 picked, the circuit to pick K2 (sequence start) remains open, and a power-on sequence cannot begin.

Note: The RESET pushbutton on the C/I must be held in for a few seconds. A momentary depression is not sufficient to reset the OV/OC reed relay, and a false indication of a second OV/OC condition will occur if the reed relay is not reset.

Thermal Check Power-Off Sequence

- Catastrophic thermal condition immediately sequences power-off.

- Thermal warning condition does not sequence power-off.
- Power is not sequenced up until the thermal condition is reset.
- Battery backup is prevented.

Two types of thermal checks can occur within the SE. One check (a thermal warning) occurs when the ambient temperature in the logic gates or in the storage areas is above 122°F, or when the temperature in one of the power tubs is above 130°F.

Detection of a thermal warning condition does not cause a power check indication at the SE other than to light the WARNING indicator (DS7). Thermal warning sensors (in both storage and the SSU) control storage relay K38 (warning thermal). When a thermal warning condition exists in a logic gate, in storage, or in a power tub, a thermal sensor opens and drops relay K38. The WARNING indicator on the storage power control lights and a 'pwr chk' signal is routed to light an indicator on the system or configuration console. An OTC signal is sent to SE logic circuitry when relay K43 (sense OTC) drops. This relay is also held energized by the N/O point of K38. The thermal warning circuitry can be reset by moving the PWR ON/OFF/RESET switch from PWR ON to RESET and back to PWR ON. (The TEST/NORMAL switch must be set to NORMAL.)

Another thermal check (thermal catastrophic) occurs when the operating temperature exceeds the safe upper limit in the logic gates, power tubs, C/I, or the storage array areas. Thermal sensors located in each of these areas control an associated thermal relay. The thermal relays are held energized through the N/C thermal sensors. When a sensor opens, its associated thermal relay drops. Four storage array sensors hold relays K5, K6, K10, and K11. One of these relays drops when the temperature in the array area exceeds 134°F. SSU power tub A2 is protected by relay SSU-K3, and storage power tubs are protected by relay K13. The power tub thermals open at 140°F. SSU and storage logic gate sensors open at 134°F and drop SSU relay K4 or storage relay K12, depending on where the thermal condition exists. The SE C/I is protected by relay K14. The thermal sensor in the C/I opens at 163°F (maximum).

The points of all thermal relays are in series in the hold circuit of storage relay K2 (start sequence). When a thermal catastrophic condition is sensed in any area, the hold circuit of K2 is broken, and the relay drops. This action initiates a power-off sequence similar to the OV/OC power-off sequence.

Except for a C/I thermal condition (which does not provide a thermal warning), a thermal warning condition exists prior to the catastrophic check. Therefore, the power check indication at the system or configuration console, the thermal check indicator at the SE, and the OTC signal to logic circuitry already exist through the N/C K38 (warning thermal) and K43 (sense OTC) relay points.

When SE power has been dropped due to a thermal overload, the thermal trip must be reset. After the temperature in the overheated area(s) drops below the thermal warning level, the PWR ON/OFF/RESET switch is set to RESET and then to PWR ON. The de-energized thermal relay(s) and K38 (warning thermal) are reset (picked) by the RESET side of the switch. The thermal relay that dropped re-establishes a hold circuit through its N/O point and the now closed high temperature thermal.

Since storage relay K1 (EPO control) remains energized through the power-off sequence, a power-on sequence begins when the PWR ON/OFF/RESET switch is returned to PWR ON. If the overheated area(s) has not cooled down sufficiently, the power-on sequence will not be completed. K45 (start delay) is picked by the PWR ON switch, but K2 (start sequence) cannot pick since the catastrophic thermal condition has not been reset.

Relay K53 (arm/disarm line sense) in the line sense and switching circuit is picked during the power-off sequence. With K53 picked, the battery backup supply is blocked from cutting in and sustaining power for an additional period of time.

CONTROLS AND INDICATORS

The following paragraphs identify and describe the controls and indicators on the SSU power control panel (Figure 4-14) and on the storage power control panel (Figure 4-15).

SSU Power Control Panel

Indicators

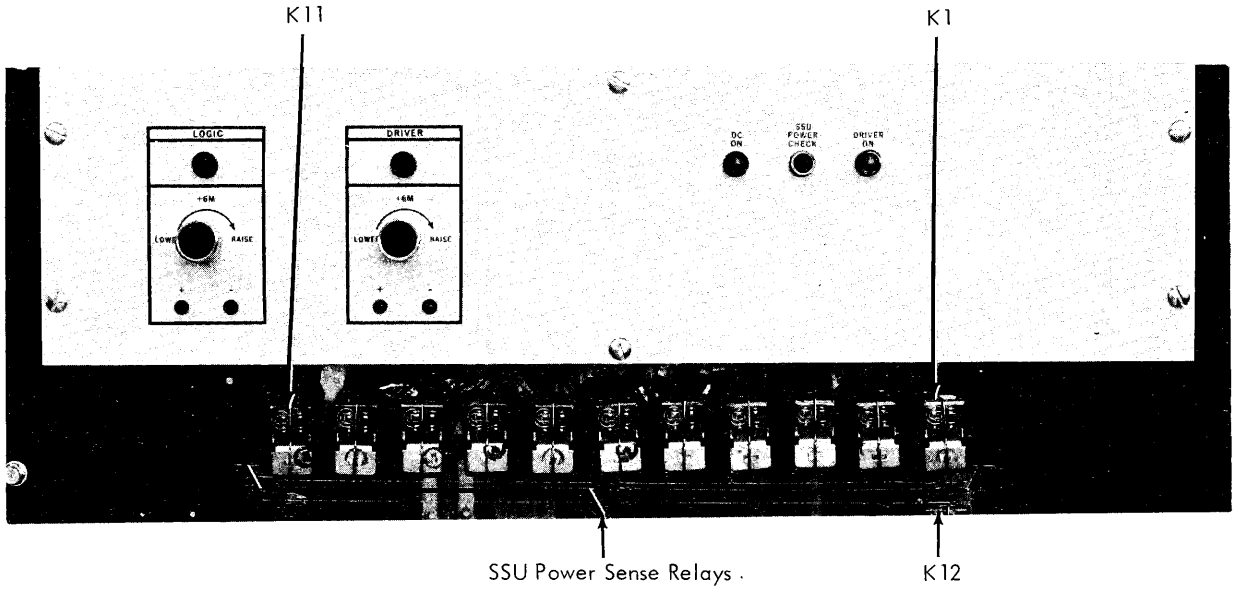
DC ON (L4): Lights when all five logic supplies in the SSU are on.

POWER CHECK (L3): Lights when an OV/OC condition exists in one of the SSU regulators.

DRIVER ON (L2): Lights when the SSU driver supply regulator A2A3 is on.

+6M LOGIC (L6): Lights when SSU regulator A2B3 is being marginally checked.

+6M DRIVER (L5): Lights when SSU regulator A2A3 is being marginally checked.



●Figure 4-14. SSU Power Control Panel

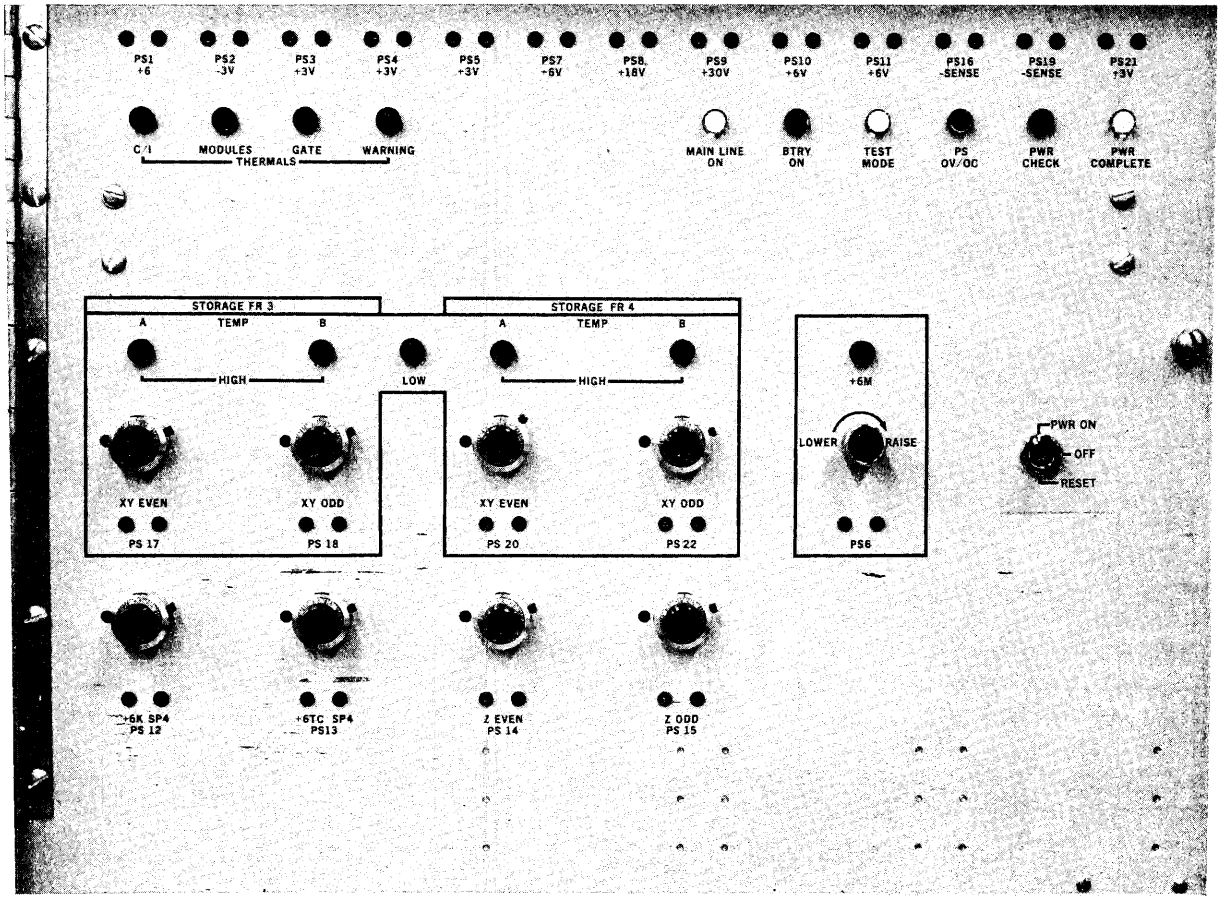


Figure 4-15. Storage Power Control Panel

Controls

Logic Margin: Varies the +6M regulator A2B3 output voltage. The element remains available to the system.

Driver Margin: Varies the +6M regulator A2A3 output voltage. The SE remains available to the system.

Storage Power Control Panel

Indicators

PWR COMPLETE (DS1): With the TEST/NORMAL switch in NORMAL, this lamp lights when all SE power supplies are on; in TEST, it lights when all SE power supplies are on except SSU regulator A2A3.

PWR CHECK (DS2): Is normally on and is extinguished when the power-on sequence is complete.

PS OV/OC (DS3): Lights when an OV/OC condition occurs. The indicator is extinguished by depressing RESET located on the C/I, and then turning the PWR ON/OFF/RESET switch to RESET.

TEST MODE (DS4): Lights when the SE is in test mode and TEST/NORMAL switch on the maintenance panel is in TEST.

BTRY ON (DS5): Lights when the SE is on battery backup power as a result of losing 208V ac prime power.

MAIN LINE ON (DS6): Lights when the ac input voltage is present beyond the load side of the input circuit breaker and no EPO/MPO condition exists.

WARNING Thermal (DS7): Lights when any of the SE thermal sensing switches detects a temperature within about 10°F of the nominal thermal protection temperature.

GATE Thermal (DS8): Lights when an overtemperature (catastrophic) condition exists in any of the five storage logic gates in frames 03 and 04 or in the four SSU logic gates in frame 02 (134°F±3°F).

MODULES Thermal (DS9): Lights when an overtemperature (catastrophic) condition exists in any of the three storage power tubs in frame 05, or the SSU power tub in frame 01 (140°F±3°F).

C/I Thermal (DS10): Lights when an overtemperature (catastrophic) condition exists in the C/I (160°F±3°F).

+6M (DS11): Lights when storage regulator 6 is being marginally checked.

STORAGE FR3 – STORAGE FR4 (DS12–16): Are associated with the four core array assemblies (two in frame 03 and two in frame 04). There are five indicators on the storage power control panel that signal array temperature conditions. The four indicators labeled HIGH indicate an overtemperature (catastrophic) condition for each associated array (115°F). A power-off sequence begins when a HIGH indicator lights. The indicator labeled LOW (DS14) indicates an array undertemperature condition in any one or all of the four arrays (86°F). During a normal power-on sequence, the indicator is on until all four arrays are up to temperature.

Controls

PWR ON/OFF/RESET Switch (S1): Is a double-pole double throw, lock ON, lock OFF, momentary RESET toggle switch. The PWR ON position initiates the power-on sequence for the SE. The OFF position initiates the power-off sequence provided that the TEST/NORMAL switch is in TEST, and the SE is in state zero. The RESET position performs three functions: (1) resets the thermal warning circuits, (2) resets the catastrophic thermal circuits, and (3) resets the OV/OC circuits.

+6K SP4 Potentiometer: Optimizes the output of the +6K current sink supply (regulator 12) during SP4 (storage protect) core array "shmooing" procedures.

+6 TC SP4 Potentiometer: Is similar to +6K SP4 but controls regulator 13.

Z EVEN Potentiometer: Optimizes the output of the Z-driver (inhibit driver) regulator 14 for the two even core arrays.

Z ODD Potentiometer: Is similar to Z EVEN but controls regulator 15.

STORAGE FR3 – STORAGE FR4: These potentiometers are associated with four core array assemblies (2 in frame 3, and 2 in frame 4). The four potentiometers control the output voltage of the four XY-driver supplies while optimizing these voltages during array "shmooing" procedures. The power supply regulators controlled by the potentiometers are: in frame 3, XY EVEN controls

regulator 17 and XY ODD controls regulator 18; in frame 4, XY EVEN controls regulator 20 and XY ODD controls regulator 22.

Test Jacks

A pair of test jacks is provided on the storage power control panel for each of the 22 storage dc regulators. These jacks allow the regulator outputs to be monitored during installation of maintenance.

TEST OBS Pushbutton (S2)

The TEST OBS (on-battery supply) pushbutton is on the rear wall of frame 5 (Figure 4-4). Pressing the pushbutton picks relay K44 (sense OBS). An on-battery condition is simulated through the N/O K44 points by forcing an OBS signal to SE logic circuitry.

TEST OTC Pushbutton (S3)

The TEST OTC (out-of-tolerance check) pushbutton is located on the rear wall of frame 5 (Figure 4-4). Pressing the pushbutton drops relay K43 (sense OTC). An OTC condition is simulated through the N/C points of K43 by forcing an OTC signal to SE logic circuitry.

ELEMENT MPO PULL (Master Power Off) Switch

The SE has one MPO switch, located at the top of frame 01 (Figure 4-2). Pulling this switch drops all hazardous voltages outside the prime power box, including convenience outlet voltage. The +24V dc and 28V ac control voltages remain active. Power is restored to the SE when the MPO switch, which is mechanically latched, is reset by maintenance personnel, and the PWR ON/OFF/RESET is in PWR ON.

All 7289-04 Display Element (DE) components and circuits associated with power distribution and control are described in this chapter. A general description of protection and checking circuits (including EPO/MPO) and the battery backup power is given in Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- The DE consists of four frames, numbered 1, 2, 3, and 5.
- Frame 1 contains SU regulators and associated power components.
- Frame 5 contains storage regulators and associated power components.
- Four functional units in DE power: converter/inverter regulators, battery backup supply, and control circuitry.

The DE consists of two basic sections. Frames 1 and 2 make up the switch unit (SU); frames 3 and 5, the storage section. Each section has its own power supplies. Frame 1 contains the power components for the SU; frame 5, the power components for the storage section.

The major functional units of DE power are the 75-amp converter/inverter (C/I), the dc regulators, the battery backup supply, and the control circuitry. The (C/I) converts 208V ac, 60-Hz, 3-phase, input power to single-phase, squarewave, 2500-Hz power. The dc regulators convert the 2500-Hz power from the C/I into the regulated dc power required by the DE. The battery backup system keeps the C/I running for 5.5 ± 0.5 seconds in case of an ac input line failure. The power control circuitry provides power control, protection, and distribution. It also satisfies power sequencing required within the DE.

The C/I, the battery backup supply, and the dc regulators are standard units used in other elements of the system (See Chapter 1). This chapter describes the components unique to the DE as well as all the DE power controls.

Figures 5-1 through 5-6 show the locations of the various components within the DE. Figure 5-1 shows an overall view of the DE. Frame 1 is in front of the DE and, in conjunction with adjacent units, forms the power wall of the system. Frame 1 contains the power supply components for the SU. The two power supply tub assemblies located in frame 1 contain the 11 SU dc regulators. The SU power control panel and the SU power sequencing relays are also located in this frame. The DE master power-off switch (MPO) is located at the upper left portion of frame 1, and the I/O panel is located at the bottom. With all machine covers on, the MPO switch is the only operator-accessible component. Frame 1 is mounted on hinges and equipped with a latch to permit access to the rear of the frame and to the tailgate (containing the element I/O cables) located on frame 2.

Frame 5 is at the rear of the DE and contains the C/I, the battery backup system, storage section dc regulators, and much of the power control circuitry. The 15 dc regulators are contained in two power tubs. One tub is permanently mounted in the center of frame 5 and the other is a swinging power tub. Also located in frame 5 are the line sense and switching circuitry, the prime power panel, and the power control panel.

Power Interlock Circuitry

- Power can be removed from the DE by: (1) system EPO switch, (2) element MPO switch, (3) removing 208V ac prime power input or, (4) turning the machine off.

With the TEST/NORMAL switch in NORMAL, power can be turned off by removing the prime power at the facility source, by operating the system EPO switch located on the Configuration Console, or by operating the element MPO switch at the top of frame 1. When the TEST/NORMAL switch is in NORMAL, interrupting the 208V ac power input results in a transfer to the battery backup supply for 5.5 seconds. If the 208V ac input power is not restored during this time, a power-down sequence follows; if input power is restored during the 5.5-second period, the DE reverts to operation on 208V ac input power after 5.5 seconds.

Both the system EPO switch and the element MPO switch are mechanically interlocked so that, if either is operated, it must be reset by maintenance personnel. Power down as a result of operating the system EPO switch or the element MPO switch does not follow the normal power-off sequence. Figure 5-7 shows that relay K1 drops whenever either of these switches is operated. Prime power is immediately removed and all the regulators are disconnected. The convenience outlets are also deactivated because K47 (convenience outlet control) drops in parallel with K1 (EPO control).

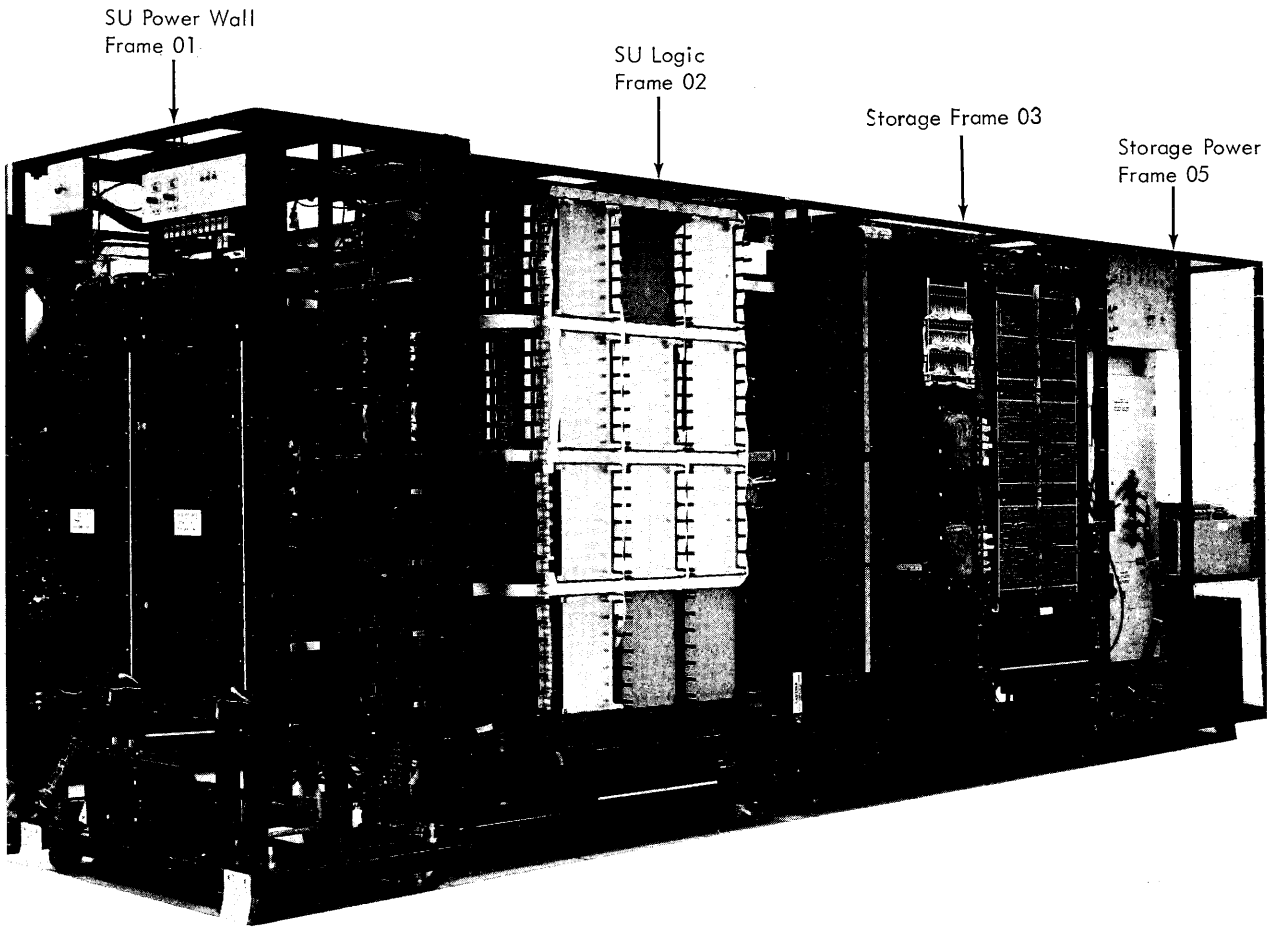


Figure 5-1. Display Element Frame Identification

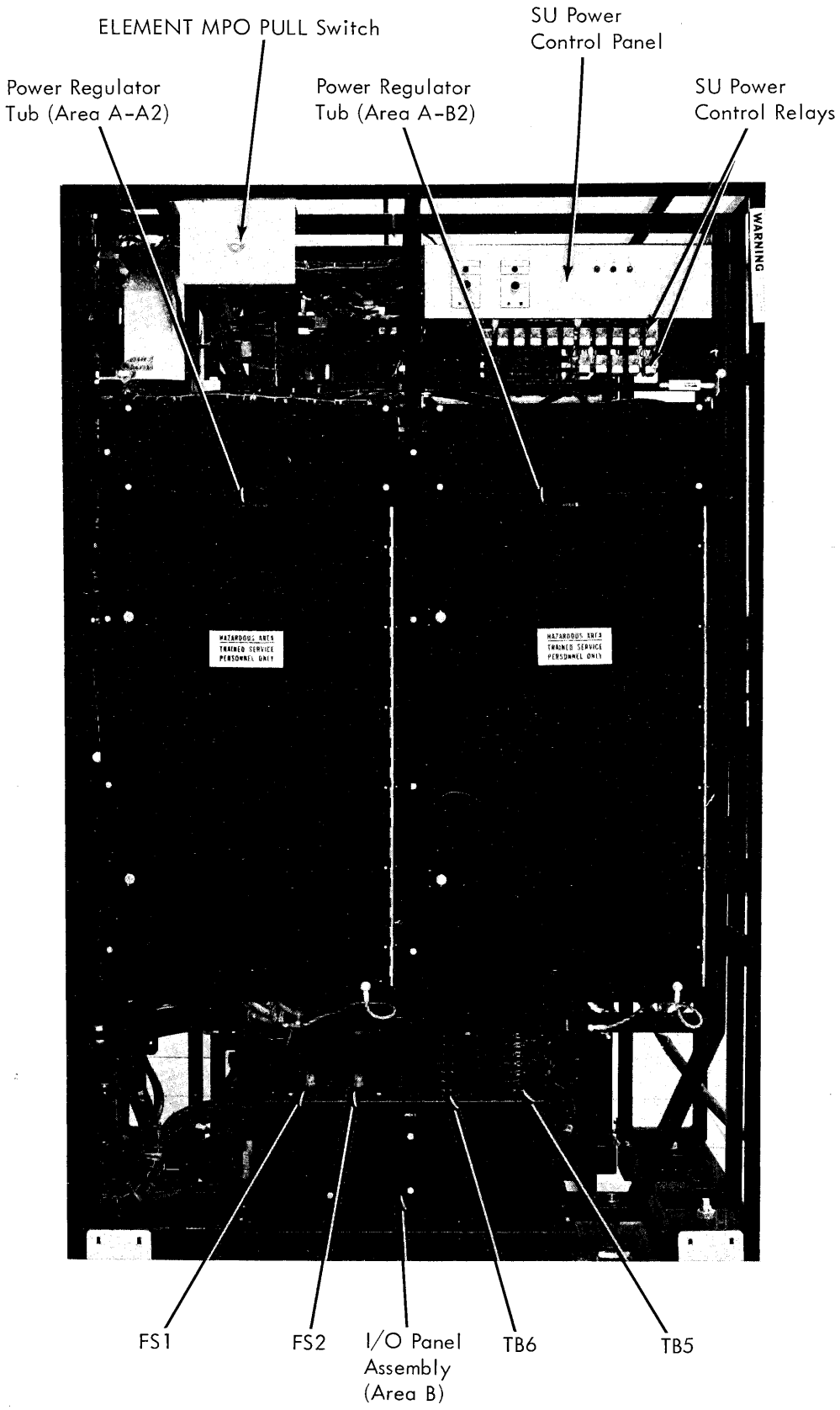


Figure 5-2. SU Power (Frame 01)

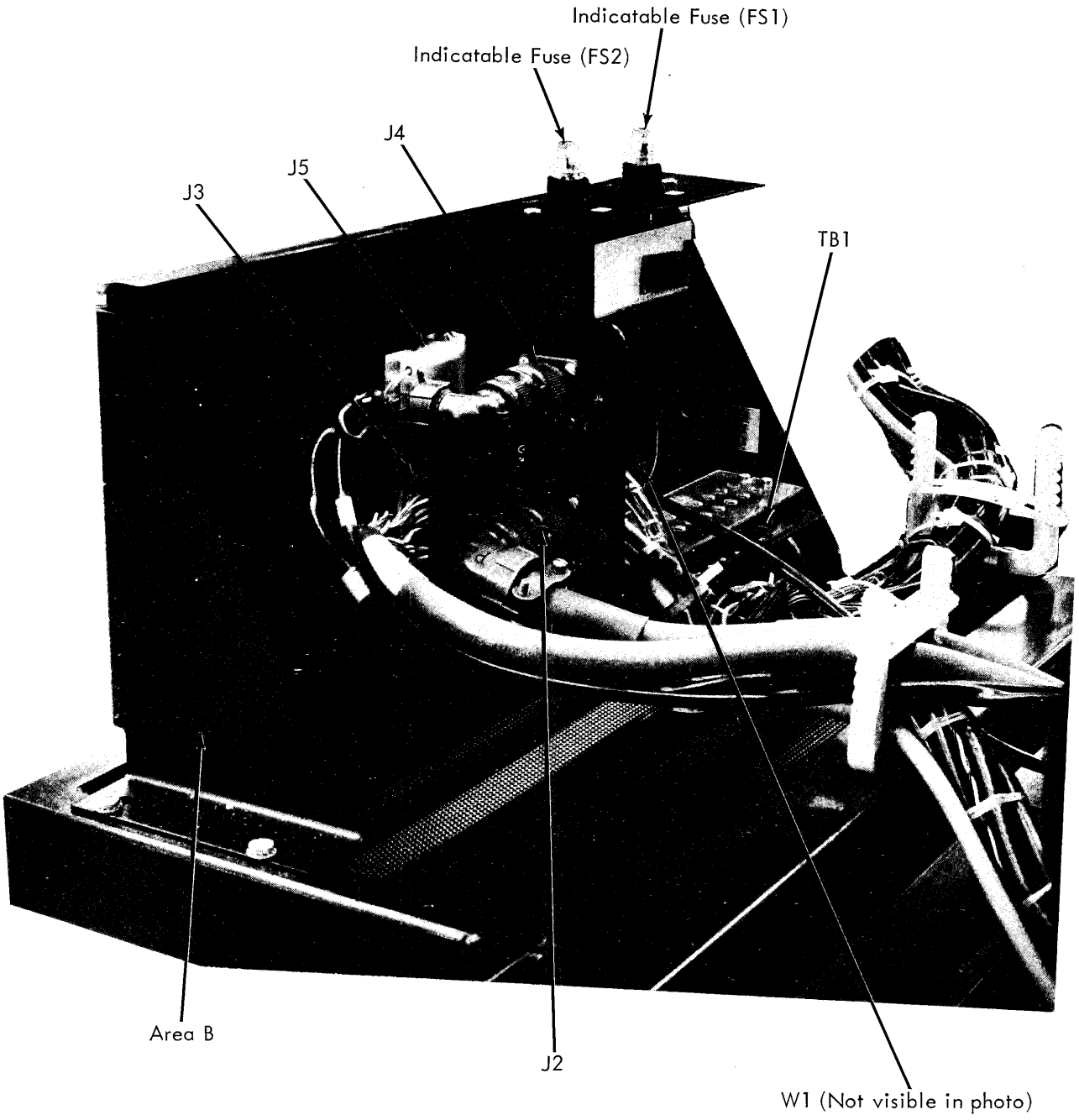


Figure 5-3. SU I/O Power Panel (Frame 01)

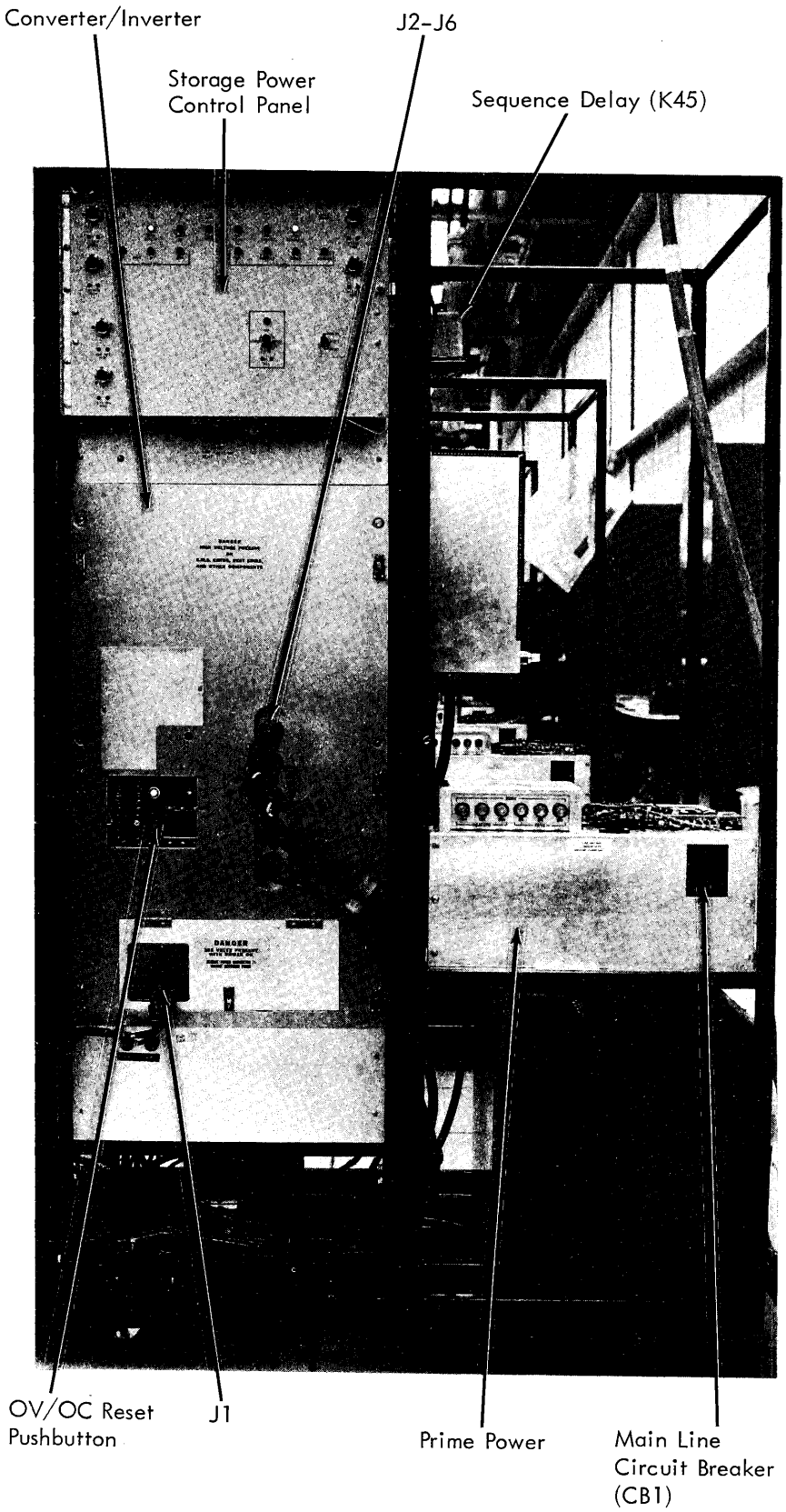


Figure 5-4. Storage Power (Frame 05)

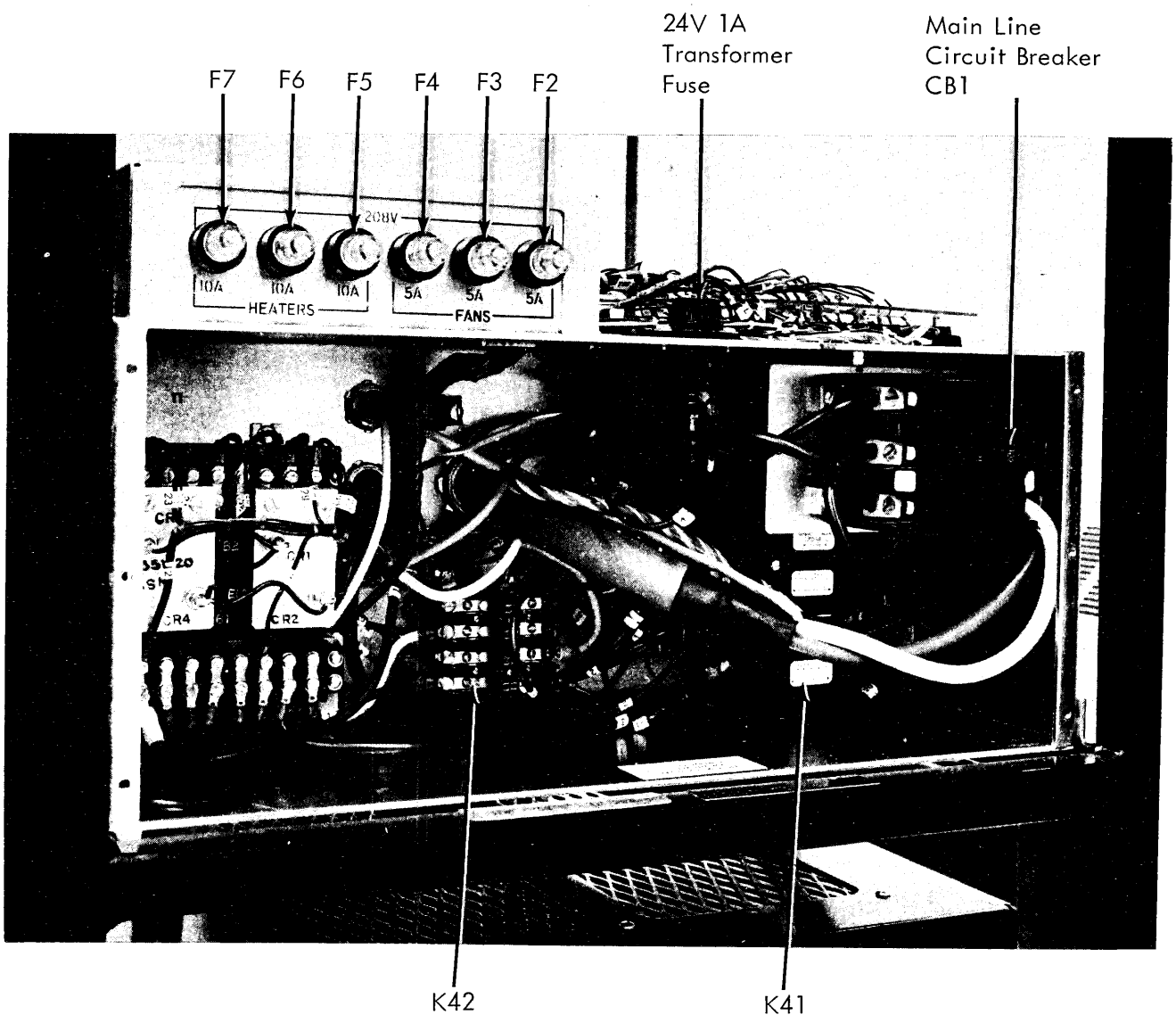
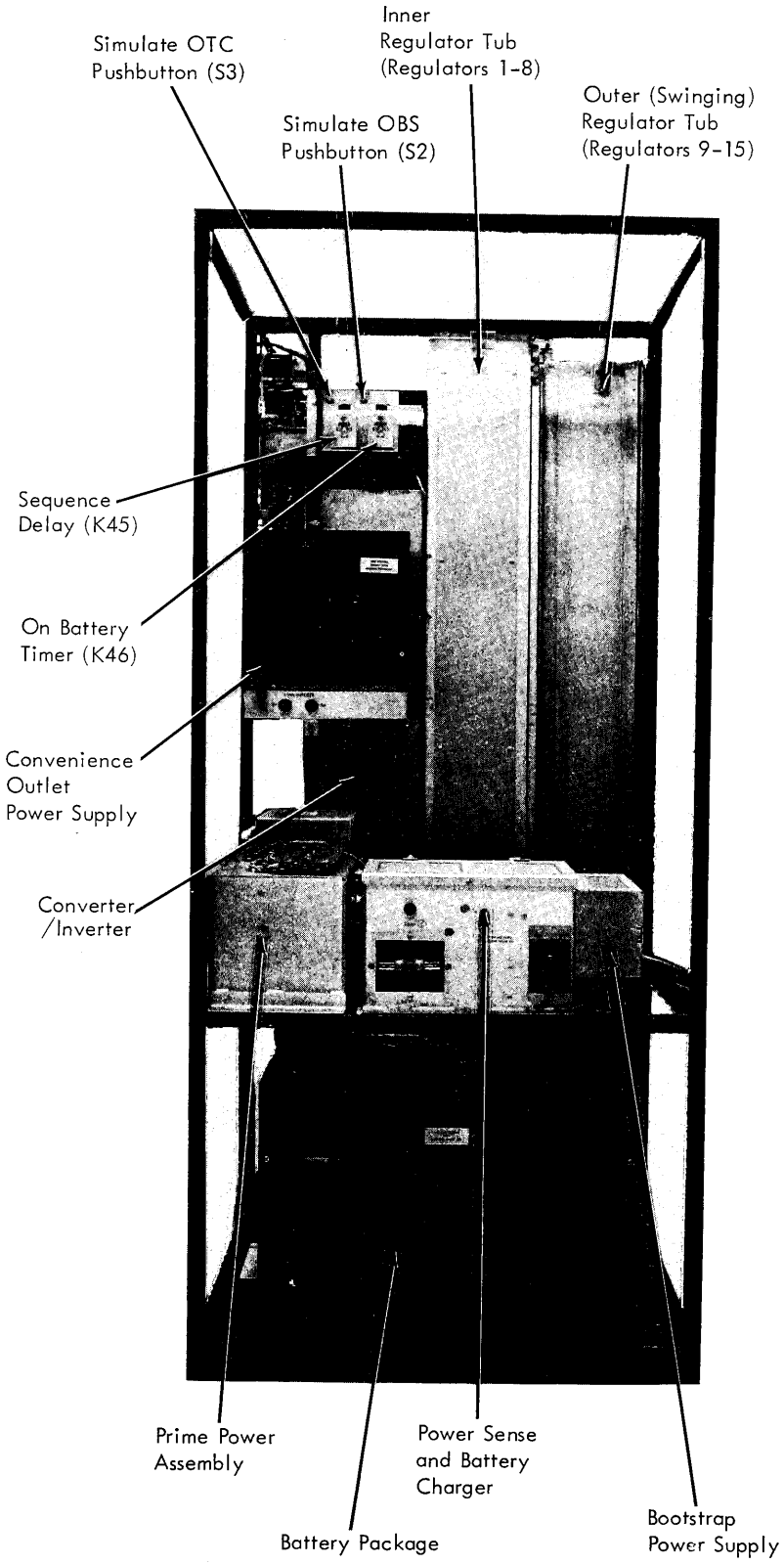


Figure 5-5. Storage Prime Power (Cover Removed)



●Figure 5-6. Storage Power (End View)

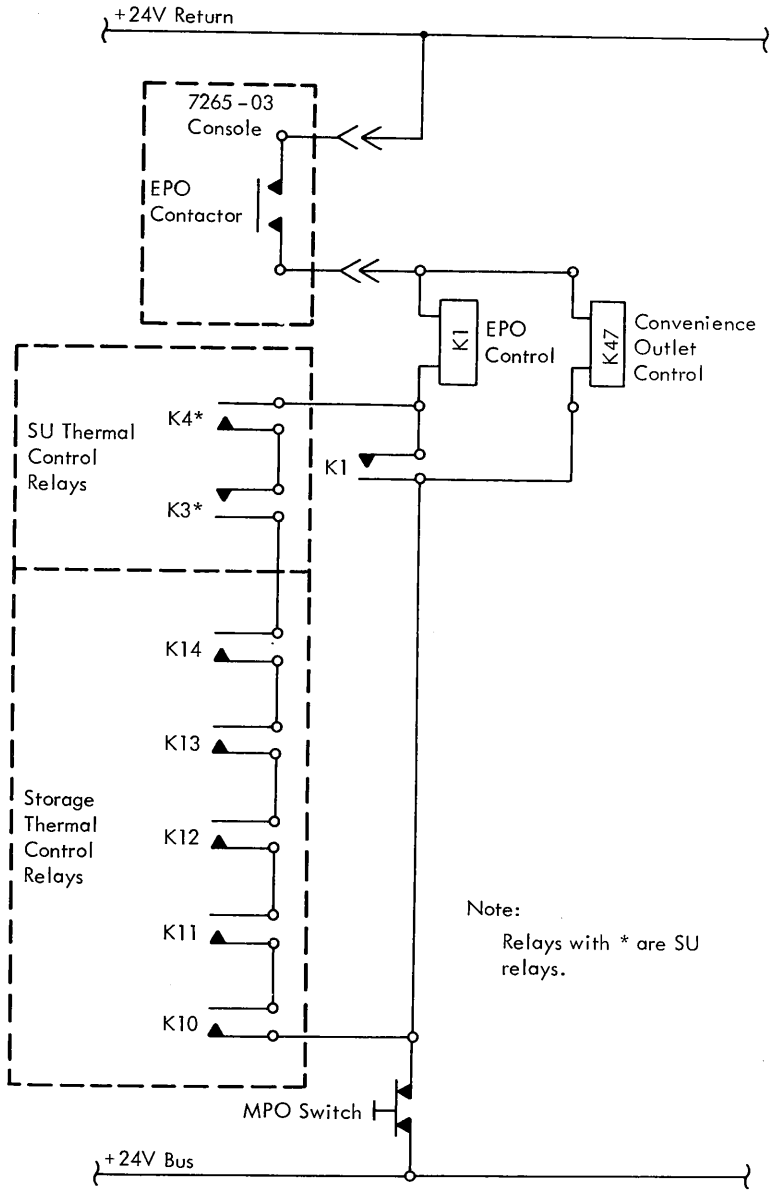


Figure 5-7. DE Power Interlock Circuitry

With both the EPO and MPO switches normal (not operated), relay K1 is picked when the SU and storage thermal relays have been picked. The power-on sequence begins when the PWR ON switch is activated.

Manual power-off under control of the PWR ON/OFF/RESET switch on the power control panel can be accomplished only when the TEST/NORMAL switch is at TEST and the DE is in state zero.

AC Distribution

- 208V ac, 3-phase, 60-Hz input voltage.
- Mainline circuit breaker rated at 40 amp.
- +24V present when mainline circuit breaker is on.
- Two mainline contactors distribute 208V ac to storage and SU sections.
- Mainline voltage is monitored by a line sense relay.

Input power to the 7289-04 DE is 208V ac, 3-phase, 60-Hz supplied by a four-wire cable. The fourth wire is a noncurrent carrying equipment ground. Maximum rms input current is 18.0 amperes at 208V. The input circuit breaker (CB1) protects DE components from damage when short circuits occur. The circuit breaker opens the mainline when 40 or more amperes are drawn.

The ac power distribution and the major ac control circuitry is shown in Figure 5-8. CB1 controls all ac input voltage to the DE. Turning CB1 on applies single-phase 208V ac through fuse F1 to the input of the 24V prime power supply. The MAINLINE ON indicator lights, indicating that CB1 is on and K1 is closed, +24V dc is available, and convenience outlet power is available for the convenience outlets. Bias is present at all dc regulators when the 24V prime power supply is energized.

Power-on contactors K41 and K42 must be energized for any further distribution of input ac voltage to occur. Pick voltage is applied to K41 and K42 in parallel through the K4 N/O points. K4 (C/I start) is energized during the power-on sequence. (The power-on sequence is described later in this chapter.)

When contactor K41 (power on) is energized, 208V ac is applied to: the C/I (through cable plug P1 and jack J1), the line sense and switching circuitry (at TB6), and to the storage section fans (through fuses F2, F3, and F4).

Power-on contactor K42, picked in parallel with K41, provides 208V ac to the SU power fan and the SU gate blowers. 208V ac is also applied to the storage section heaters through 10-amp fuses F5, F6, and F7.

Line sense relay K33 picks through an N/O point on contactor K41. Points of the line sense relay are used in the battery-on and battery-off sequences to indicate the presence or absence of prime power.

DC Distribution

- All dc logic voltages derived from dc regulators.
- 26 regulators are used in DE.
- 137 (rms), 2.5-kHz square wave from C/I power regulators.
- Low-voltage regulators sequence on first.
- High-voltage regulators sequenced on last.
- Storage protect supplies (regulators 9 and 12) powered by regulator 5.
- All regulator outputs are relay sensed.
- Regulator power supply tubs are protected by thermal sensors that detect overtemperature conditions.

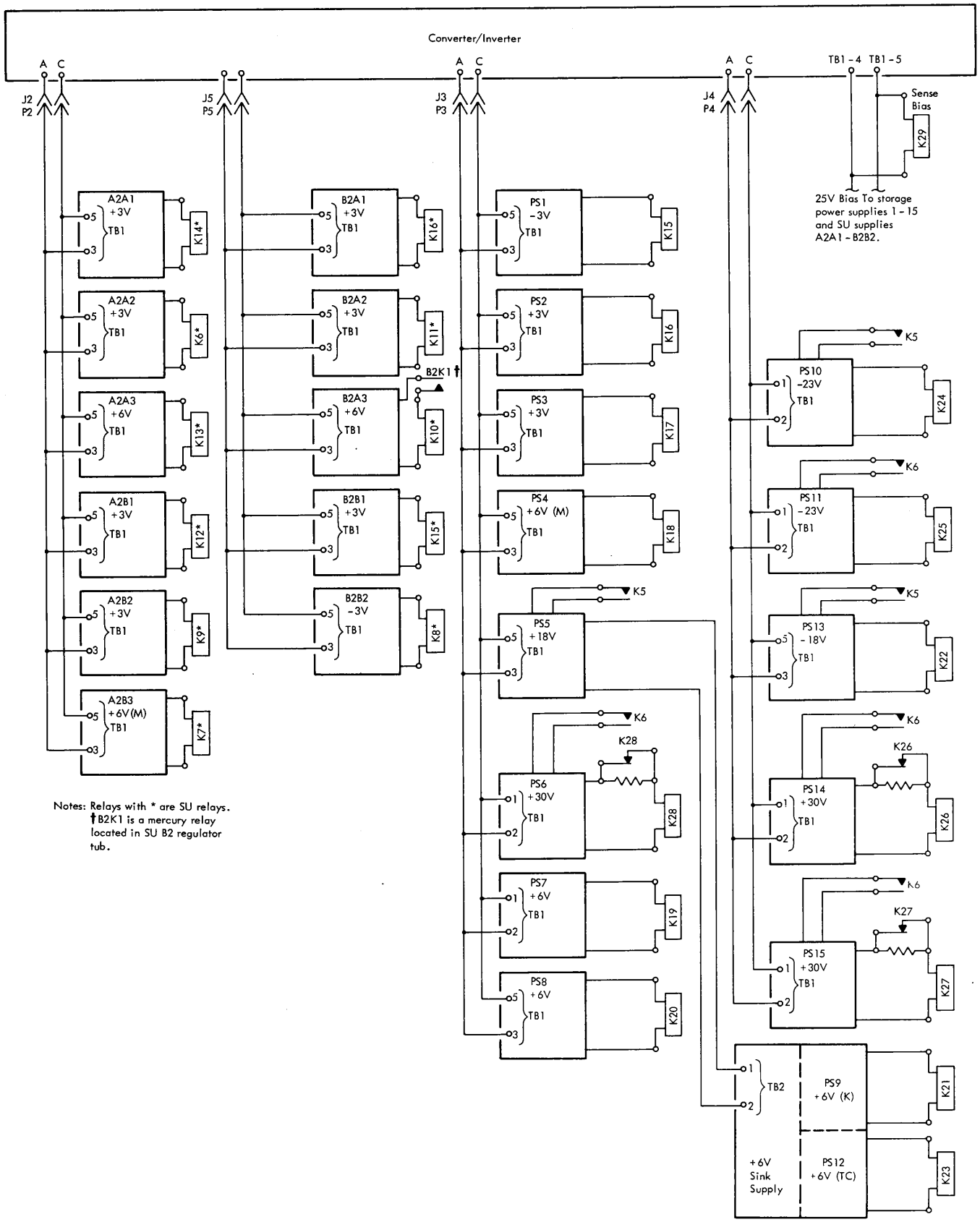
Figure 5-9 shows the DE regulator supplies and controls. All dc voltages used by the DE except the power sequence and control voltage are obtained from the regulators. The DE uses 26 dc regulators.

Circuitry in the individual regulators provides the desired dc output voltage. Regulator output current and voltage is monitored to protect the regulators. Should either the current or the voltage exceed the upper limit, a short circuit (axe) is placed across the output, the regulator shuts off, and the sequence and control circuitry is signaled to begin a power-down sequence.

Each regulator output (except PS5) is monitored by a sense relay which also controls the proper power-on and power-off sequencing in the DE. The sense relays are connected directly across the output of the regulators. The HV regulators have a 300-ohm resistor in series with the sense relay coil.

Input power to the dc regulators is a 137V (rms), 2.5-kHz, square wave from the C/I. The 2.5-kHz is supplied to the regulators via four cables from the C/I. Jacks J2 and J5 supply the regulators in the two SU power tubs. Jacks J3 and J4 feed the regulators in the two storage section power tubs.

The C/I also supplies +25V bias voltage to all regulators. TB1 in the C/I is the output terminal block for the +25V



Notes: Relays with * are SU relays.
†B2K1 is a mercury relay located in SU B2 regulator tub.

●Figure 5-9. Display Element DC Regulators and Controls

bias. Relay K29 senses the presence of bias voltage, and its points are used to control the power-on and the power-off sequences.

The regulators are sequenced on in two groups. SU and storage +3V, -3V, +6V, and +6V (M) regulators are energized as soon as output from the C/I is available. Storage relays K5 and K6 are energized by sequencing control circuitry to bring up the HV supplies.

SU interface driver voltage regulator B2A3 is under control of relay B2K1. When the TEST/NORMAL switch is set to TEST and the DE is in state 0, relay B2K1 drops, and the output of regulator B2A3 drops, thereby removing the driver voltage from SU circuitry.

SU Regulators

The SU uses 11 dc regulators. Table 5-1 lists the 11 regulators and gives additional information about current ratings, logic reference pages, and logic page locations. Each regulator has a sense relay, used in the power-on and power-off sequence, that picks when the regulator delivers its output voltage. The sense relay remains energized as long as the regulator continues to provide output voltage. The sense relays are mounted at the bottom of the SU power control panel.

Temperature in the power supply tubs is monitored by thermal switches located above the regulators. A 130°F thermal lights THERMAL WARNING indicator DS7 on the storage power control panel. The 140° thermal picks SU relay K3 and lights MODULE THERMAL indicator DS9 when that temperature is exceeded.

Storage Regulators

Table 5-2 lists the 15 storage section dc regulators and gives additional information about current ratings and logic locations. The regulators are mounted in two power supply tubs in frame 5 of the DE. The inner, rigidly mounted power tub contains regulators 1–8. The swinging power tub contains regulators 9–15.

Special voltages required for the storage protect circuitry (SP4) are developed by dc regulators 9 (+6K) and 12 (+6TC). These two storage-protect sink supplies are powered by the +18V output of dc regulator 5.

The two power supply tubs are temperature-protected by two thermal sensing switches located at the top of each tub. A thermal warning is indicated when one of the two 130°(F) thermal switches opens. A power-down sequence begins when one of the two 140°(F) thermal switches opens.

Power-On Sequence

- Automatic power-on sequence when prime power is applied.
- Adjustable time delay relay staggers system power on.
- Low-voltage supplies power-up first.
- High-voltage supplies power-up when all LV supplies are energized.

The DE performs an automatic power-on sequence as soon as primary power is applied on the PWR ON/OFF/RESET switch on the storage power control panel is on. The sequence is under control of time delay relay K45 (start dly) which is adjustable from 5 to 30 seconds of delay. Each element in the system contains a similar relay. The relays are adjusted to stagger the times at which various elements power-up.

The DE power sequence and control circuitry is shown in Figure 5-10. Figure 5-11 shows the power-on sequence. Logic page YD010 presents the power-on sequence in timing chart form.

Low-Voltage Sequencing

The power-on sequence begins when the DE is connected to primary power and mainline circuit breaker CB1 is turned on. Input voltage is applied to the prime power supply which provides +24V dc output. The +24V dc prime power supply also provides 28V ac to the C/I. The C/I rectifies this 28V ac to produce the 25V dc bias used by the dc regulators. Storage thermal relays K9–K14, K31, bias sense relay K29, sense OTC relay K43, convenience outlet relay K47, and SU relays K3 and K4 are energized through the K1 N/C relay point and the +24V dc bus. The thermal relays hold through their own N/O points and their associated N/C thermal switches. K9, the array low-temperature relay, drops when the two BSMs come up to operating temperature. Storage relay K1 energizes when the SU and storage thermal relays pick.

The PWR ON switch on the storage power control panel is turned on to continue the power-on sequence. Adjustable start delay relay K45 picks through the PWR ON switch. Relay K45 is adjustable from 5 to 30 seconds of delay before the points transfer. K2 (start sequence) picks after waiting the preset delay time for K45 to transfer. K4 (C/I start) picks through the N/O K2 points.

The 208V ac power-on contactors K41 and K42 pick in parallel through the N/O K4 points, and K45 drops through

Table 5-1. SU Regulator Data

Regulator	Nominal Voltage	Ampere Rating (Nom)	Logic Location	Logic Reference	Sense Relay
A2A1	+3	40	YC025	YF035	K14
A2A2	+3	40	YC030	YF035	K6
A2A3	+6M	40	YC040	YF036	K13
A2B1	+3	20	YC030	YF279	K12
A2B2	+3	40	YC030	YF035	K9
A2B3	+6M	40	YC030	YF036	K7
B2A1	+3	40	YC025	YF035	K16
B2A2	+3	40	YC040	YF035	K11
B2A3	+6	40	YC050	YF034	K10
B2B1	+3	40	YC025	YF035	K15
B2B2	- 3	40	YC040	YF035	K8

Table 5-2. Storage Regulator Data

Regulator	Nominal Voltage	Ampere Rating (Nom)	Logic Location	Logic Reference	Sense Relay
1	- 3	40	YD060	YF035	K15
2	+3	40	YD060	YF035	K16
3	+3	40	YD060	YF035	K17
4	+6M	40	YD060	YF036	K18
5	+18	10	YD070	YF025	
6	+30	5	YD070	YF280	K28
7	+6	40	YD070	YF034	K19
8	+6	40	YD070	YF034	K20
* 9	6K	1	YD070	YF375	K21
10	- 23	40	YD080	YF026	K24
11	- 23	40	YD080	YF026	K25
*12	6TC	1	YD080	YF375	K23
13	- 18	6.5	YD080	YF025	K22
14	+30	12	YD080	YF377	K26
15	+30	12	YD080	YF377	K27

*Regulators 9 and 12 comprise the +6V sink supply.

the K4 N/C points. 208V ac is provided to the input of the C/I, the line sense and battery charger circuitry, storage fans, storage heaters, SU power fan, and the gate blowers through the N/O points of K41 and K42. Relay K33 (line sense) picks through a K41 N/O point and stays energized as long as 208V ac line voltage is present. The C/I output is applied to the storage and SU dc regulators. The outputs of the storage regulators pick their associated sense relays K15–K20. When the SU regulators deliver output voltage, their corresponding SU sense relays, K6–K9 and K11–K16, pick. Regulator sense relays remain energized as long as there is output voltage from the regulator. As soon as storage sense relay K15 and K16 transfer, relays K52 and K54 in the line sense and switching circuit pick in parallel. Relays K52 and K54 are held energized during normal power-on conditions. SU relay K2 picks, and the DC ON indicator (L4) lights through the N/O points of the +3V, -3V, and +6V sense relays connected in series.

High-Voltage Sequencing

Since all the +3V, -3V, and +6V logic supplies are now energized, storage relays K8 (bootstrap transfer), K5, and K6 (HV PS turn-on relay) pick through SU relay K2. The remaining +30V, +18V, -18V, and -23V storage regulators are energized through the N/O points of storage relays K5 and K6. When the storage HV regulators come up, they pick the HV sense relays K21–K28. The remaining element supply (SU regulator B2A3) is energized through the N/O points of B2K1 if the TEST/NORMAL switch is in NORMAL. Regulator sense relay SU K10 is picked by the regulator output voltage.

The SU DRVR ON indicator (L2) lights through a K10 N/O point. Another K10 N/O point picks relays K3 (power check) and K7 (sequence complete). The power-on sequence is completed when PWR CHECK indicator (DS2) is extinguished by K3 N/C point opening, relay K53 drops through a now opened K7 N/C point, and PWR COMPLETE indicator DS1 comes on.

Normal Power-Off Sequence

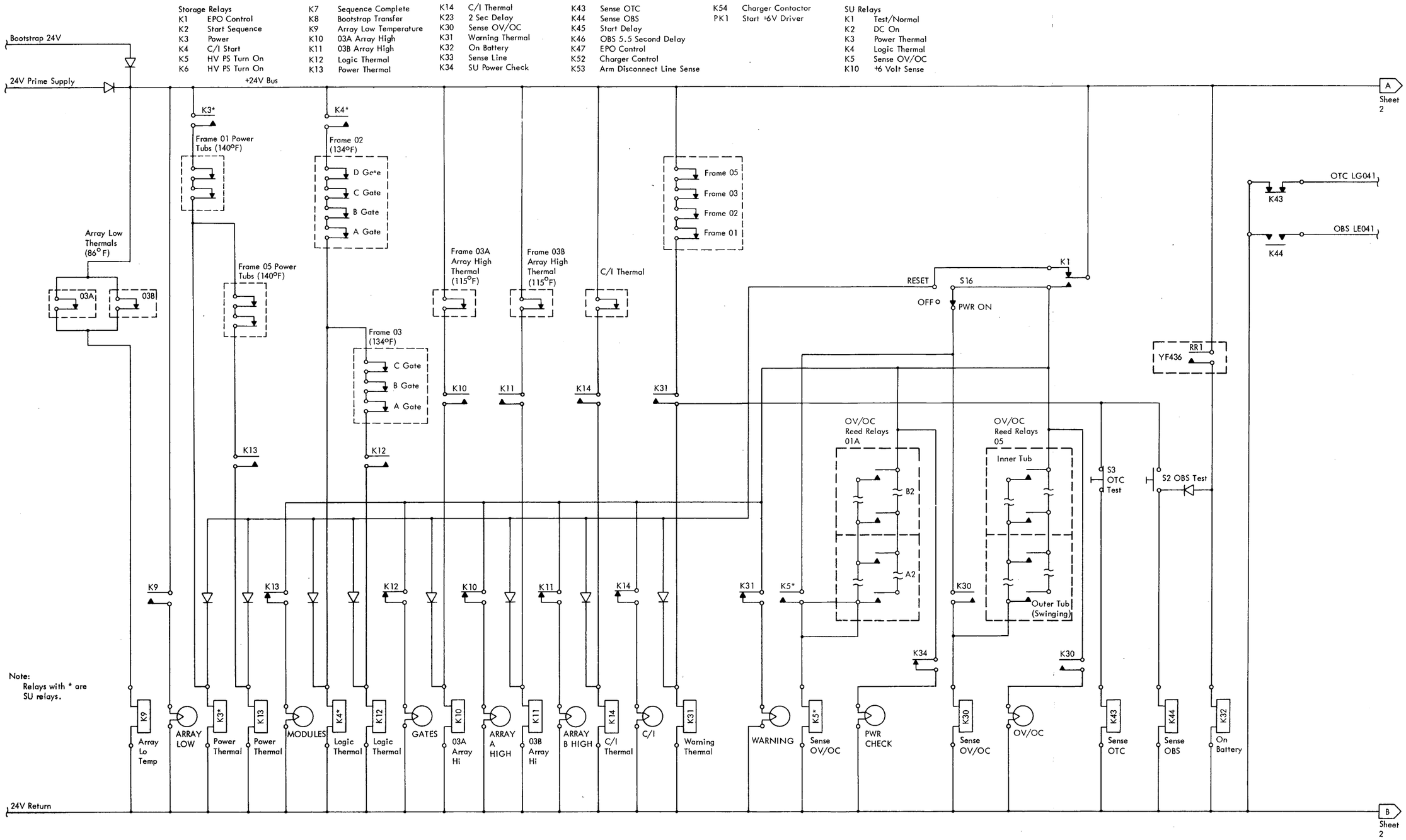
- TEST/NORMAL switch must be in TEST.
- PWR ON/OFF/RESET switch in OFF initiates power-off sequence.
- Battery backup supply is deactivated.
- Sequence down is performed in two steps: HV regulators drop first; LV regulators drop when all HV regulators are de-energized.
- Certain control relays remain energized when power-off sequence is completed.

Normal power-off, under control of the PWR ON/OFF/RESET switch, is described in Figure 5-12. The DE power sequence and control circuitry is shown in Figure 5-10. Normal power-off can be performed only when the TEST/NORMAL switch is in TEST and the DE is in state zero. SU relay K1 (test/normal) picks under control of the 'test mode' signal generated by the TEST/NORMAL switch located on the DE maintenance panel. SU relay B2K1 (start +6V driver) drops when its hold circuit is broken by energizing SU relay K1. SU regulators B2A3's sense relay (SU K10) drops when the regulator output voltage decays. Because relay K7 (sequence complete) is held through an N/O K10 point, it drops when the K10 point opens. However, PWR COMPLETE indicator DS1 remains lit since SU relay K2 (dc on) is still energized, and one of its N/O points completes the circuit to keep the indicator lit. Battery backup is prevented from cutting in by picking K53–K7 N/C points.

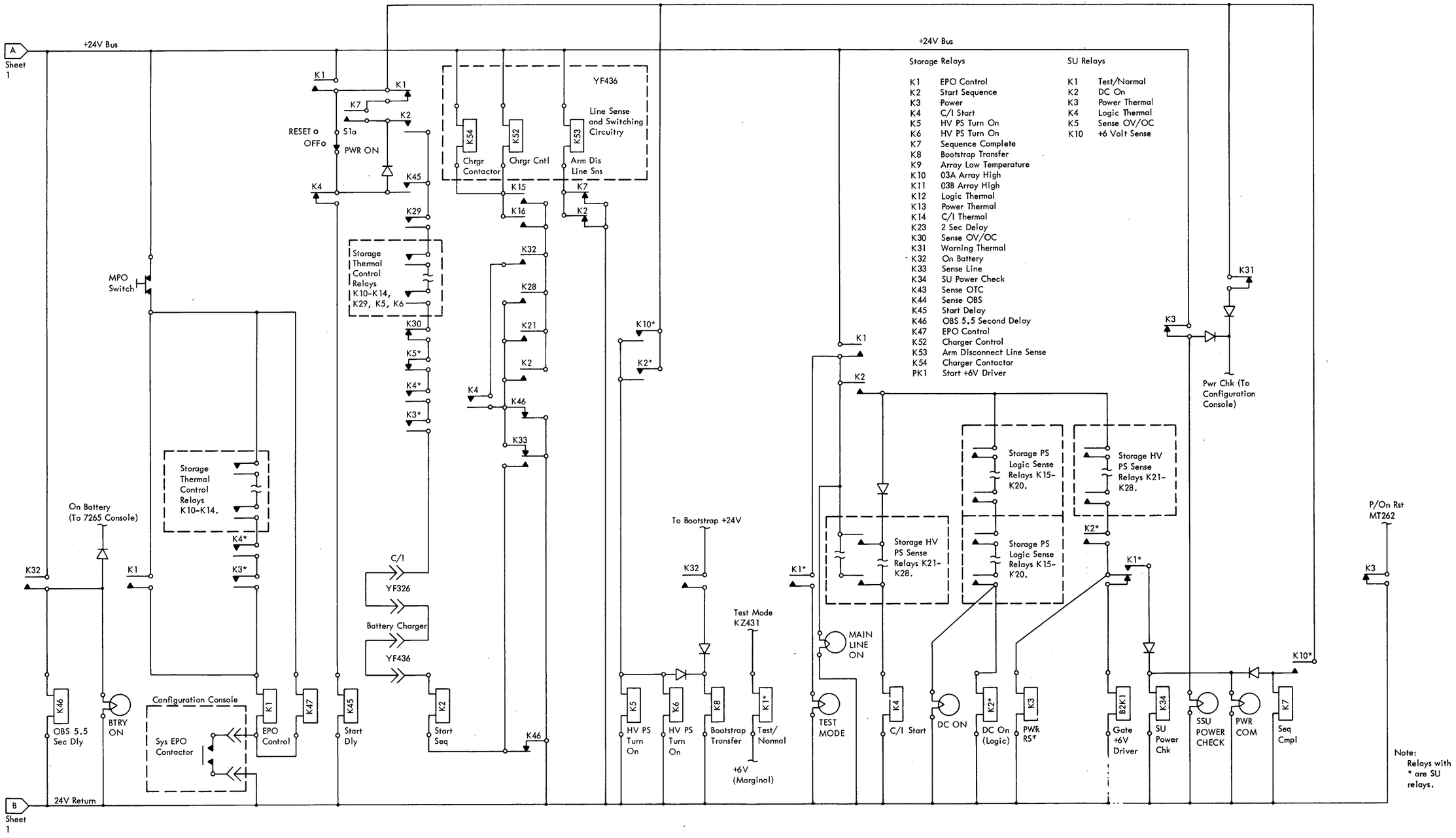
The DE is now in a condition to power-down under control of the PWR ON/OFF/RESET switch located on the storage power control panel. When the switch is turned to OFF, storage relay K2 (start sequence) drops. The relay was held energized through the PWR ON switch in its normal (PWR ON) position. SU relay K2 (dc on) drops, and DC ON indicator L4 is extinguished through a storage relay K2 N/O point. Storage relay K3 (power check) drops, and PWR COMPLETE indicator DS1 is extinguished since they both were held energized by a K2 N/O point. Storage relays K5 and K6 (HV PS turn on) drop when the hold circuit (SU relay K2 N/O) is opened.

Input to the HV power supplies is under control of the N/O points of storage relays K5 and K6. When they drop, the N/O points open, and the input to the regulators is interrupted. Storage power regulators 6 and 9–15 drop. Their associated sense relays K21–K28 drop when the regulators cease to provide an output voltage. When all HV regulator sense relays are down, storage relay K4 (C/I start) drops. In the line sense and switching circuit, relay K52 (charger control) and contactor K54 (charger contactor) drop, since their hold circuit was through HV sense relays K21 N/O and K28 N/O, both of which are down.

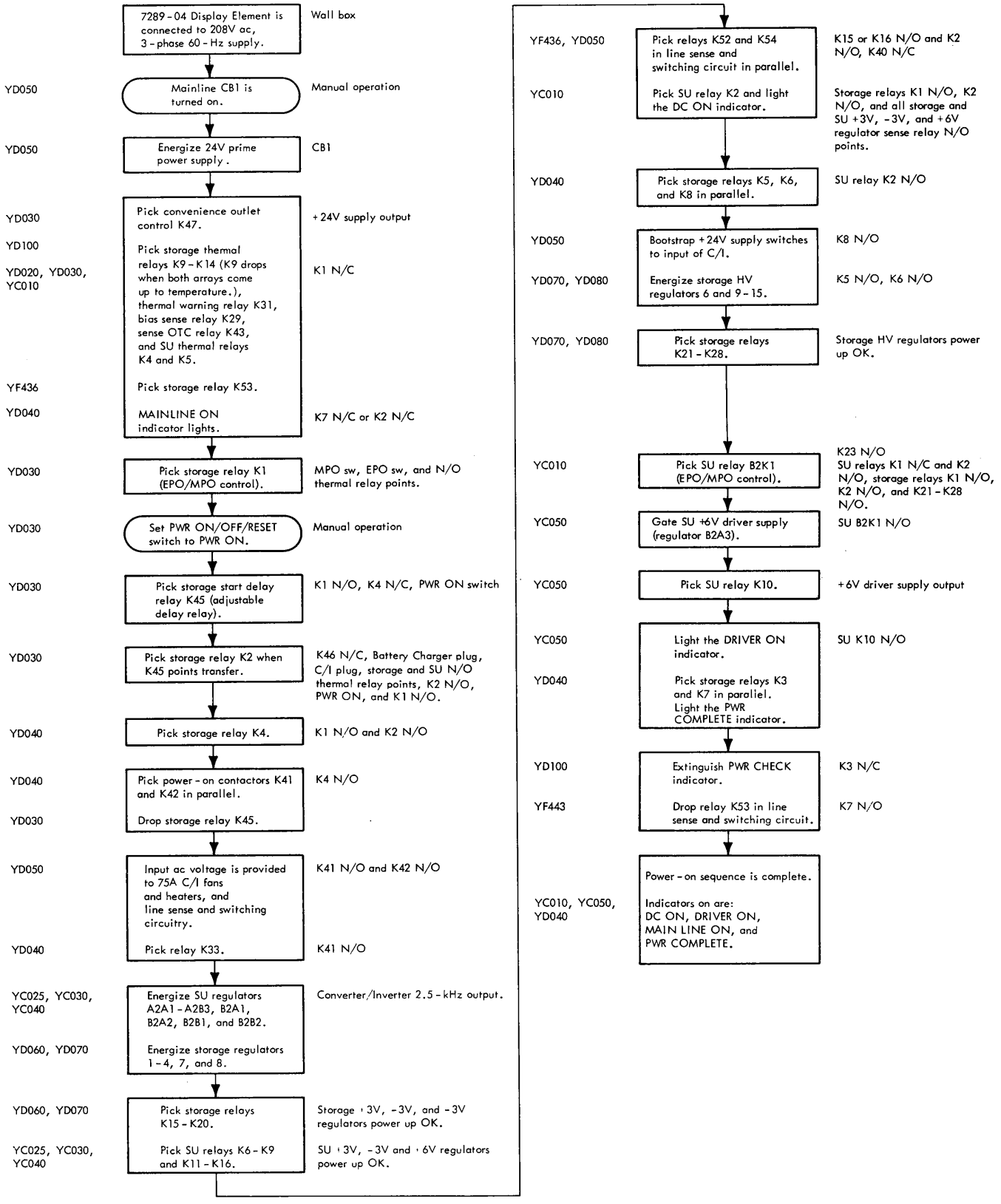
Power-on contactors K41 and K42 drop in parallel when K4 N/O opens their hold circuits. With the power-on contactors down, the 208V ac, 3-phase input to the C/I is removed. Storage relay K33 (line sense) drops because its



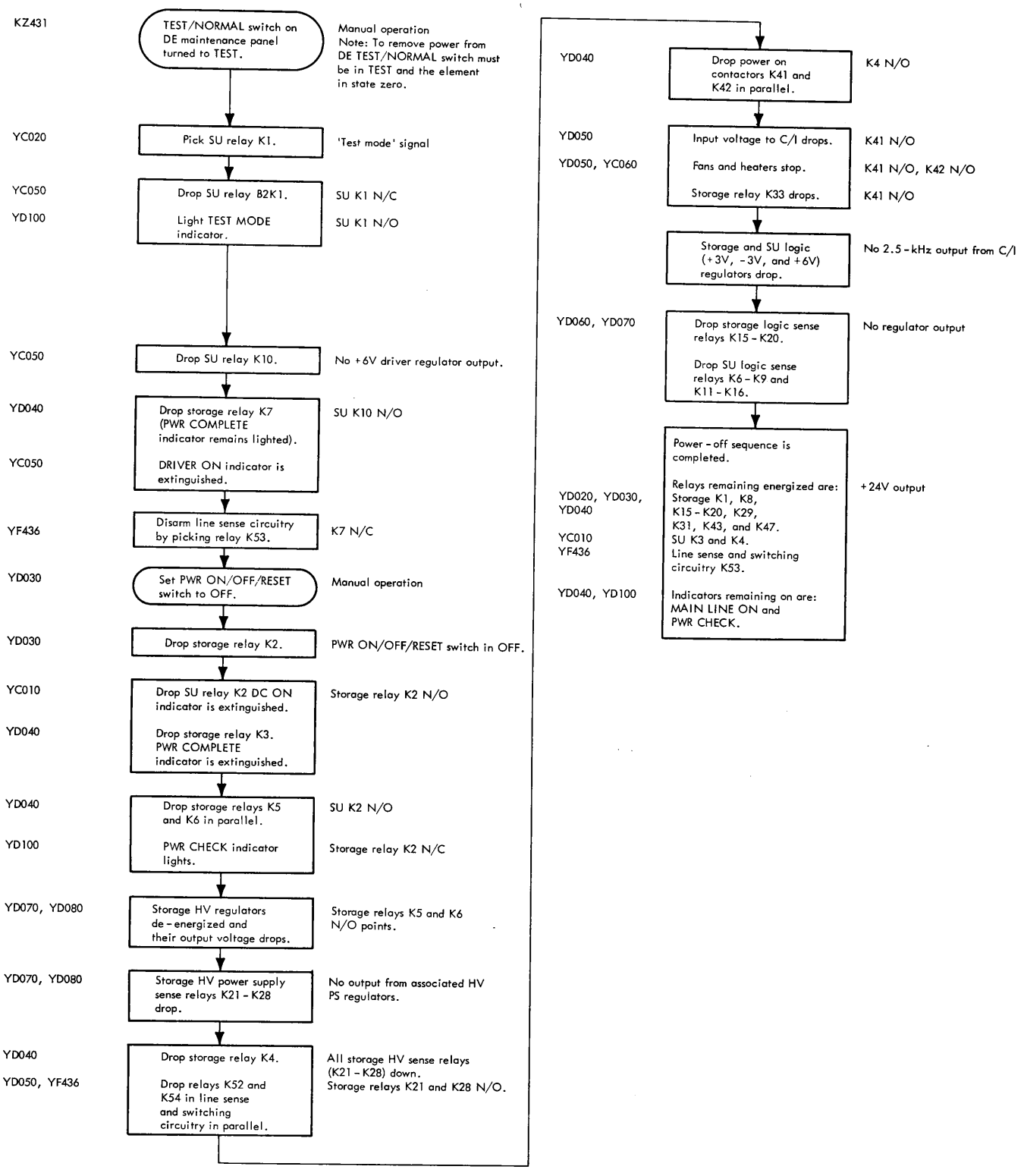
●Figure 5-10. Power Sequence and Control Circuitry (Sheet 1 of 2)



●Figure 5-10. Power Sequence and Control Circuitry (Sheet 2 of 2)


7289-04 Display Element is connected to 208V ac, 3-phase 60-Hz supply.
Wall box
YD050
Mainline CB1 is turned on.
Manual operation
YD050
Energize 24V prime power supply.
CB1
YD030
Pick convenience outlet control K47.
+24V supply output
YD100
YD020, YD030, YC010
Pick storage thermal relays K9-K14 (K9 drops when both arrays come up to temperature.), thermal warning relay K31, bias sense relay K29, sense OTC relay K43, and SU thermal relays K4 and K5.
K1 N/C
YF436
Pick storage relay K53.
YD040
MAINLINE ON indicator lights.
K7 N/C or K2 N/C
YD030
Pick storage relay K1 (EPO/MPO control).
MPO sw, EPO sw, and N/O thermal relay points.
YD030
Set PWR ON/OFF/RESET switch to PWR ON.
Manual operation
YD030
Pick storage start delay relay K45 (adjustable delay relay).
K1 N/O, K4 N/C, PWR ON switch
YD030
Pick storage relay K2 when K45 points transfer.
K46 N/C, Battery Charger plug, C/I plug, storage and SU N/O thermal relay points, K2 N/O, PWR ON, and K1 N/O.
YD040
Pick storage relay K4.
K1 N/O and K2 N/O
YD040
Pick power-on contactors K41 and K42 in parallel.
K4 N/O
YD030
Drop storage relay K45.
YD050
Input ac voltage is provided to 75A C/I fans and heaters, and line sense and switching circuitry.
K41 N/O and K42 N/O
YD040
Pick relay K33.
K41 N/O
YC025, YC030, YC040
Energize SU regulators A2A1-A2B3, B2A1, B2A2, B2B1, and B2B2.
Converter/Inverter 2.5-kHz output.
YD060, YD070
Energize storage regulators 1-4, 7, and 8.
YD060, YD070
Pick storage relays K15-K20.
Storage +3V, -3V, and -3V regulators power up OK.
YC025, YC030, YC040
Pick SU relays K6-K9 and K11-K16.
SU +3V, -3V and +6V regulators power up OK.
YF436, YD050
Pick relays K52 and K54 in line sense and switching circuit in parallel.
K15 or K16 N/O and K2 N/O, K40 N/C
YC010
Pick SU relay K2 and light the DC ON indicator.
Storage relays K1 N/O, K2 N/O, and all storage and SU +3V, -3V, and +6V regulator sense relay N/O points.
YD040
Pick storage relays K5, K6, and K8 in parallel.
SU relay K2 N/O
YD050
Bootstrap +24V supply switches to input of C/I.
K8 N/O
YD070, YD080
Energize storage HV regulators 6 and 9-15.
K5 N/O, K6 N/O
YD070, YD080
Pick storage relays K21-K28.
Storage HV regulators power up OK.
YC010
Pick SU relay B2K1 (EPO/MPO control).
K23 N/O
SU relays K1 N/C and K2 N/O, storage relays K1 N/O, K2 N/O, and K21-K28 N/O.
YC050
Gate SU +6V driver supply (regulator B2A3).
SU B2K1 N/O
YC050
Pick SU relay K10.
+6V driver supply output
YC050
Light the DRIVER ON indicator.
SU K10 N/O
YD040
Pick storage relays K3 and K7 in parallel. Light the PWR COMPLETE indicator.
YD100
Extinguish PWR CHECK indicator.
K3 N/C
YF443
Drop relay K53 in line sense and switching circuit.
K7 N/O
Power-on sequence is complete.
YC010, YC050, YD040
Indicators on are: DC ON, DRIVER ON, MAIN LINE ON, and PWR COMPLETE.

●Figure 5-11. DE Power-On Flowchart


KZ431
TEST/NORMAL switch on DE maintenance panel turned to TEST.
Manual operation
Note: To remove power from DE TEST/NORMAL switch must be in TEST and the element in state zero.
YC020
Pick SU relay K1.
'Test mode' signal
YC050
Drop SU relay B2K1.
SU K1 N/C
YD100
Light TEST MODE indicator.
SU K1 N/O
YC050
Drop SU relay K10.
No +6V driver regulator output.
YD040
Drop storage relay K7 (PWR COMPLETE indicator remains lighted).
SU K10 N/O
YC050
DRIVER ON indicator is extinguished.
YF436
Disarm line sense circuitry by picking relay K53.
K7 N/C
YD030
Set PWR ON/OFF/RESET switch to OFF.
Manual operation
YD030
Drop storage relay K2.
PWR ON/OFF/RESET switch in OFF.
YC010
Drop SU relay K2 DC ON indicator is extinguished.
Storage relay K2 N/O
YD040
Drop storage relay K3. PWR COMPLETE indicator is extinguished.
YD040
Drop storage relays K5 and K6 in parallel.
SU K2 N/O
YD100
PWR CHECK indicator lights.
Storage relay K2 N/C
YD070, YD080
Storage HV regulators de-energized and their output voltage drops.
Storage relays K5 and K6 N/O points.
YD070, YD080
Storage HV power supply sense relays K21-K28 drop.
No output from associated HV PS regulators.
YD040
Drop storage relay K4.
All storage HV sense relays (K21-K28) down.
YD050, YF436
Drop relays K52 and K54 in line sense and switching circuitry in parallel.
Storage relays K21 and K28 N/O.
YD040
Drop power on contactors K41 and K42 in parallel.
K4 N/O
YD050
Input voltage to C/I drops.
K41 N/O
YD050, YC060
Fans and heaters stop.
K41 N/O, K42 N/O
Storage relay K33 drops.
K41 N/O
Storage and SU logic (+3V, -3V, and +6V) regulators drop.
No 2.5-kHz output from C/I
YD060, YD070
Drop storage logic sense relays K15-K20.
Drop SU logic sense relays K6-K9 and K11-K16.
No regulator output
Power-off sequence is completed.
YD020, YD030, YD040
Relays remaining energized are: Storage K1, K8, K15-K20, K29, K31, K43, and K47.
+24V output
YC010
SU K3 and K4.
YF436
Line sense and switching circuitry K53.
YD040, YD100
Indicators remaining on are: MAIN LINE ON and PWR CHECK.

●Figure 5-12. DE Power-Off Flowchart

hold circuit is through a K41 N/O point. 208V ac is also removed from all heaters and fans when the N/O points of contactors K41 and K42 open.

All storage and SU power supplies cease to provide output voltage because the C/I no longer provides 2.5-kHz square-wave input to the regulators. As the output voltage from each regulator drops, the associated sense relay for that regulator also drops. The SU sense relays that drop are K6–K9 and K11–K16; the storage relays that drop are K15–K20.

The normal power-off sequence is completed. Thermal relays K1, K8, K29, and K53 (all in the storage section) remain energized. Convenience outlet power remains available with the DE power off since K47 also remains energized. These relays remain energized until 208V ac input voltage is removed from the DE by opening mainline circuit breaker CB1, or until a power fault occurs.

Battery Backup Power Control

- Uninterrupted battery backup for 5.5 seconds following power loss.
- Loss of primary power is sensed as a decay of converter dc output within the C/I.
- Battery backup power is not applied under EPO/MPO conditions.

The DE has a battery backup power source that permits uninterrupted power for 5.5 ± 0.5 seconds following the loss of 208V ac primary input power.

Loss of primary input power is detected as a voltage decay on the bus between the converter and inverter sections of the C/I. When this voltage drops below a preset limit (about 240V dc), a preconditioned silicon-controlled rectifier, (SCR) in the line sense and switching circuit conducts and feeds battery power to the input of the inverter section in the C/I, thus allowing the C/I to continue providing uninterrupted input to the dc regulators.

Under conditions where prime power is not restored within 5.5 seconds, the DE begins a power-off sequence. Figure 5-13 shows the DE battery backup power operation when prime power is restored within 5.5 seconds after loss, and when prime power is not restored within 5.5 seconds. The power-off sequence that results in the latter case is also described.

Battery Backup with Prime Power Restored

- Battery backup supply is switched in automatically.
- Battery supply is active for 5.5 seconds.

Loss of 208V ac input power is sensed by the line sense and switching circuitry. An SCR (silicon-controlled rectifier) in that circuit switches the battery supply output to the input of the inverter circuit in the C/I. Since there is no longer any ac input voltage to the DE, the 24V prime power supply output drops, mainline contactors K41 and K42 and line sense relay K33 drop, and the fans and heaters stop. Through the N/O reed relay point in the line sense circuitry, relays K32 (battery on) and K44 (sense OBS) pick. The K32 point turns on the BTRY ON indicators (DS5) on the storage power control panel, and the BATTERY indicator on the CC operator's panel. An OBS (on-battery supply) signal is also sent to the DE logic circuitry through N/O K44 points. Switching to battery power also starts the 5.5-second delayed-pick K46 (OBS 5 second delay) timing out.

If mainline 208V ac power is restored before the points of K46 transfer (5.5 seconds after pick voltage is applied), the DE remains in a power-on condition. If the K46 points transfer before mainline power is restored, a power-off sequence begins. The power-off sequence is described in later paragraphs.

The 24V prime power supply is energized as soon as the 208V ac input voltage is restored. Power-on contactors K41 and K42 pick since there is now an output voltage from the prime power supply. The fans and heaters resume operation, and K33 (line sense) picks through the K41 points.

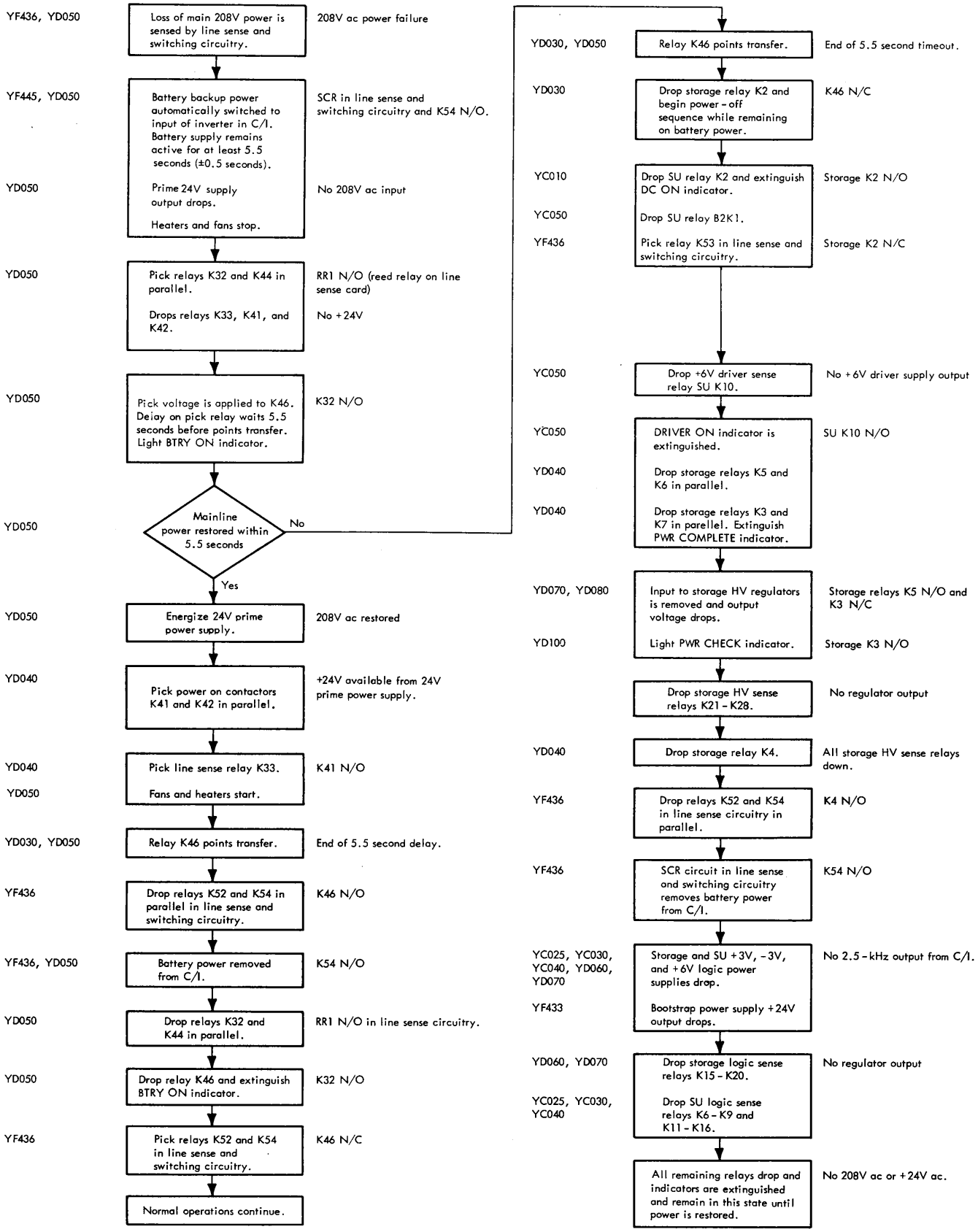
Battery power is used for 5.5 seconds even though mainline power is restored. When the K46 points transfer at the end of 5.5 seconds, relay K52 (charger control) and contactor K54 (charger contactor) in the line sense and switching circuit drop because the hold circuit through the N/C K46 point no longer exists. The K54 N/C points reapply potential to the anode of the switching SCR, enabling it to conduct on the next demand from the sensing circuit. K54 N/O points also remove the battery supply output from the C/I.

Relays K32 and K44 drop in parallel under control of the reed relay in the line sense circuit. Because K46 and the BTRY ON indicator are energized through K32 N/O relay, K46 drops and the BTRY ON indicator goes out. Relay K52 and contactor K54 pick through K46 N/C.

The DE is again operating from prime power, the line sense and switching circuits is re-established, and the battery backup package is ready for another emergency.

Battery Backup without Prime Power Restored

- 5.5 seconds on battery backup.
- Begin power-off sequence after 5.5 seconds.
- Power can automatically sequence on when prime power input returns.


YF436, YD050
Loss of main 208V power is sensed by line sense and switching circuitry.
208V ac power failure
YF445, YD050
Battery backup power automatically switched to input of inverter in C/I. Battery supply remains active for at least 5.5 seconds (±0.5 seconds).
SCR in line sense and switching circuitry and K54 N/O.
YD050
Prime 24V supply output drops.
Heaters and fans stop.
No 208V ac input
YD050
Pick relays K32 and K44 in parallel.
RR1 N/O (reed relay on line sense card)
Drops relays K33, K41, and K42.
No +24V
YD050
Pick voltage is applied to K46. Delay on pick relay waits 5.5 seconds before points transfer. Light BTRY ON indicator.
K32 N/O
YD050
Mainline power restored within 5.5 seconds
No
Yes
YD050
Energize 24V prime power supply.
208V ac restored
YD040
Pick power on contactors K41 and K42 in parallel.
+24V available from 24V prime power supply.
YD040
Pick line sense relay K33.
K41 N/O
YD050
Fans and heaters start.
YD030, YD050
Relay K46 points transfer.
End of 5.5 second delay.
YF436
Drop relays K52 and K54 in parallel in line sense and switching circuitry.
K46 N/O
YF436, YD050
Battery power removed from C/I.
K54 N/O
YD050
Drop relays K32 and K44 in parallel.
RR1 N/O in line sense circuitry.
YD050
Drop relay K46 and extinguish BTRY ON indicator.
K32 N/O
YF436
Pick relays K52 and K54 in line sense and switching circuitry.
K46 N/C
Normal operations continue.
YD030, YD050
Relay K46 points transfer.
End of 5.5 second timeout.
YD030
Drop storage relay K2 and begin power-off sequence while remaining on battery power.
K46 N/C
YC010
Drop SU relay K2 and extinguish DC ON indicator.
Storage K2 N/O
YC050
Drop SU relay B2K1.
YF436
Pick relay K53 in line sense and switching circuitry.
Storage K2 N/C
YC050
Drop +6V driver sense relay SU K10.
No +6V driver supply output
YC050
DRIVER ON indicator is extinguished.
SU K10 N/O
YD040
Drop storage relays K5 and K6 in parallel.
YD040
Drop storage relays K3 and K7 in parellel. Extinguish PWR COMPLETE indicator.
YD070, YD080
Input to storage HV regulators is removed and output voltage drops.
Storage relays K5 N/O and K3 N/C
YD100
Light PWR CHECK indicator.
Storage K3 N/O
Drop storage HV sense relays K21-K28.
No regulator output
YD040
Drop storage relay K4.
All storage HV sense relays down.
YF436
Drop relays K52 and K54 in line sense circuitry in parallel.
K4 N/O
YF436
SCR circuit in line sense and switching circuitry removes battery power from C/I.
K54 N/O
YC025, YC030, YC040, YD060, YD070
Storage and SU +3V, -3V, and +6V logic power supplies drop.
No 2.5-kHz output from C/I.
YF433
Bootstrap power supply +24V output drops.
YD060, YD070
Drop storage logic sense relays K15-K20.
No regulator output
YC025, YC030, YC040
Drop SU logic sense relays K6-K9 and K11-K16.
All remaining relays drop and indicators are extinguished and remain in this state until power is restored.
No 208V ac or +24V ac.

●Figure 5-13. DE Battery Back-Up Power Flowchart

When the SCR switches battery power into the DE, reed relay 1 (RR1) picks in the line sense and switching circuit and provides a pick circuit for relays K32 (battery on) and K44 (sense OBS). As previously described, the K32 points turn on the BTRY ON indicator (DS5) on the DE power control panel and provide an OBS (on-battery supply) signal to DE logic circuitry.

If at the end of the 5.5-second delay prime power is not restored, relay K46 points transfer, and the power-off sequence begins. K46 N/C opens the hold circuit for storage relay K2 (start sequence). K2 N/O points drop SU relay K2 (dc on), SU relay B2K1 (start +6V driver), pick relay K53 in line sense circuitry, and extinguish the DC ON indicator on the SU power control panel. SU relay K10, the sense relay for regulator B2A3, drops when the regulator output voltage drops. SU-K10 N/O points open the hold circuit for storage relays K3 (power check) and K7 (sequence complete) and extinguish the DRIVER ON indicator (L2). The PWR COMPLETE indicator (DS1) is extinguished in parallel with storage relay K7 dropping. The hold circuit for storage relay K5 and K6 (start HV power supply input) is open since both K2 and K10 are down.

Input to the storage HV regulators is removed when storage relays K5 and K6 N/O points open. Because 2.5-kHz input from the C/I is no longer delivered to the HV regulators, the regulator outputs decay, and associated sense relays K21–K28 also drop. K4 (C/I start) drops when all of the HV sense relays open. The K4 N/O points drop K52 and K54 in the line sense and switching circuit.

Contactor K54 opens the SCR anode circuit which supplies battery power to the C/I. Without 2.5-kHz C/I output, the last dc voltage group (+3V, -3V, and +6V logic supplies) and the bootstrap power supply turn off. Relays K32 and K44 also drop since holding voltage is no longer available.

At the completion of the power-off sequence, all remaining relays drop, and all indicators are extinguished. However, since the PWR ON/OFF/RESET switch is in PWR ON, power is automatically sequenced up when primary power is restored.

Emergency Power-Off Sequence

- EPO and MPO conditions immediately remove all power, except 24V prime power supply.
- Normal power-off sequencing is bypassed.
- Battery backup is prevented under EPO/MPO conditions.

If either the system EPO or the element MPO switch is pulled, all power is turned off in the DE except the +24V dc and 28V ac control voltages provided by the 24V prime power supply. The EPO and MPO switches are mechanical latch types that must be reset manually. Pulling the MPO switch has no effect on system power, but pulling the system EPO switch removes power from all attached elements.

Refer to Figures 5-7 and 5-10. Pulling either the EPO switch or the MPO switch drops storage relays K1 (EPO control) and K47 (convenience outlet control). The dropping of K1 drops the +24V dc bus that holds storage relays K2–K8 and SU relays K2 and B2K1. Convenience outlet power is removed when relay K47 drops. Relay K53 (arm/disarm line sense), located in the line sense and switching circuit, picks through N/C K2 and K7 points in parallel. Picking K53 prevents the battery backup supply from cutting in. Power-on contactors K41 and K42 drop because their hold circuit through the N/O K4 points is broken as a result of K4 having dropped. Fans, blowers, and heaters stop under control of K41 and K42.

All storage HV regulators drop because storage relays K5 and K6 interrupted the square-wave input from the C/I. Their associated sense relays drop when the regulators cease to provide output voltage. The output of SU regulator B2A3 is degated when SU relay B2K1 drops. Its sense relay (SU-K10) drops when the regulator output voltage decays. Since the power-on contactors are down, storage relay K33 (line sense) also drops.

EPO/MPO power-off sequencing continues when all remaining storage and SU regulators drop. All the storage and SU LV sense relays drop when the LV regulators stop providing output voltage. Relay K52 (charger control) and contactor K54 (charger contactor), both located in the line sense and switching circuitry, drop in parallel.

When the EPO/MPO power-off sequencing is completed, the 24V dc prime power supply still provides +24V dc and 28V ac. Therefore, certain control relays (thermal sensing) remain energized. Since the EPO and the MPO switches contain mechanical interlocks, automatic power sequencing cannot begin until the switch that was pulled is reset by maintenance personnel.

CAUTION

When the EPO or MPO switch is reset, the DE will sequence back on if the PWR ON/OFF/RESET switch is in PWR ON, and DE protective circuitry (OV/OC, thermal, etc.) has not been activated prior to pulling the MPO or EPO switch.

Special Power-Off Sequences

Two categories of special power-off sequences are described in the following text. These sequences result from the detection of an OV/OC condition of a dc regulator or an overtemperature (thermal) condition in the DE.

Overvoltage/Overcurrent Power-Off Sequence

- Each regulator has an OV/OC sense circuit.
- An OV/OC condition automatically sequences power off.
- Power does not sequence up until the OV/OC condition is reset.
- Battery backup is prevented under OV/OC condition.

Each storage and SU regulator in the DE has an OV/OC sense circuit. If an OV/OC condition occurs in a regulator, its respective sense circuit picks a reed relay located on a OV/OC SMS card internal to the supply. The N/O contacts of any sense relay that detects an OV/OC condition in the storage section picks storage relay K30 (sense OV/OC), and lights the OV/OC indicator (DS3). An OV/OC condition in the SU picks SU relay K5 and lights OV/OC indicator (L3). K30 holds through its own N/O points. The N/C K30 points break the hold circuit for storage relay K2 (start sequence). In the line sense and switching circuit, K52 (arm/disarm line sense) picks to prevent the battery backup supply from cutting in. The DE begins a power-off sequence similar to the "Normal Power-Off Sequence" described earlier. The timing chart on logic page YD010 shows the power-off sequence in detail.

During the power-off sequence, K30 remains energized through the pick circuit (the N/O sense reed relay point) and through a hold circuit established by the N/O K30 point in series with the PWR ON/OFF/RESET switch. To restore power to the DE, the OV/OC condition must be reset manually at the C/I, and the PWR ON/OFF/RESET switch must be turned to RESET, then to PWR ON.

Pressing RESET at the C/I drops the OV/OC sense reed relay at the regulator. The reed relay N/O point opens the pick circuit for K30 (or SU-K5). K30 continues to hold through the PWR ON/OFF/RESET switch. When this switch is turned to RESET, K30 drops. The N/C K30 point re-establishes the pick circuit for storage relay K2 (sequence start) so a normal power-on sequence (described earlier) can begin when the PWR ON/OFF/RESET switch is returned to PWR ON.

If the OV/OC condition is not reset before the PWR ON/OFF/RESET switch is activated, K30 will continue to hold through the N/O reed relay point. With K30 picked, the circuit to pick K2 (sequence start) remains open, and a power-on sequence cannot begin.

Note: The RESET pushbutton on the C/I must be held in for a few seconds. A momentary depression is not sufficient to reset the OV/OC reed relay, and a false indication of a second OV/OC condition will occur if the reed relay is not reset.

Thermal Check Power-Off Sequence

- Catastrophic thermal condition immediately sequences power-off.
- Thermal warning condition does not sequence power-off.
- Power is not sequenced up until the thermal condition is reset.
- Battery backup is prevented.

Two types of thermal checks can occur within the DE. One check (thermal warning) occurs when the ambient temperature in the storage areas or in the logic gates is above 122°F, or when the temperature in one of the power tubs is above 130°F.

Thermal warning sensors control storage relay K31 (warning thermal). When a thermal warning condition exists in either a logic gate, in storage, or in a power tub, relay K31 drops. The WARNING indicator (DS7) on the storage power control lights, and a 24V 'pwr chk' signal is routed to light an indicator on the Configuration Console. An OTC signal is sent to DE logic circuitry when relay K43 (sense OTC) drops. This relay is also held energized by the N/O point of K31.

Detection of a thermal warning condition does not cause a power check indication at the DE other than to light the WARNING indicator, nor does it initiate a power-off sequence. The thermal warning circuitry can be reset by moving the PWR ON/OFF/RESET switch from the PWR ON position to RESET and back to PWR ON. (The TEST/NORMAL switch must be set to NORMAL.)

Another thermal check (thermal catastrophic) occurs when the operating temperature exceeds the safe upper limit in the logic gates, power tubs, C/I, or the storage array areas. Thermal sensors located in each of these areas control an associated thermal relay. The thermal relays are held energized through the N/C thermal sensing switches. When a switch opens, its associated thermal relay drops. Thermal relays K10 and K11 hold through the two storage array thermal switches. One of these relays drops when the temperature in an array exceeds 115°F. SU power tubs A2 and B2 are protected by relay SU-K3, and storage power tubs are protected by storage relay K13. The power tub thermals open at 140°F. SU and storage logic gate thermal switches open at 134°F and drop SU relay K4 or storage relay K12, depending on where the thermal condition exists. The DE C/I is protected by relay K14. The thermal switch in the C/I opens at 163°F (maximum).

The points of all thermal relays are in series in the hold circuit of storage relay K2 (start sequence). When a thermal catastrophic condition is sensed in any area, the hold circuit

of K2 is broken, and the relay drops. This action initiates a power-off sequence similar to the OV/OC power-off sequence.

Except for a C/I thermal condition (which does not provide a thermal warning), a thermal warning condition exists prior to the catastrophic check. Therefore, the power check indication at the Configuration Console, the THERMAL CHECK indicator at the DE, and the OTC signal to logic circuitry already exist through the N/C K31 (warning thermal) and K43 (sense OTC) relay points.

The procedure for restoring power to the DE is to correct the cause of the thermal condition, and, when the area has cooled, turn the PWR ON/OFF/RESET switch to RESET and then back to PWR ON. The de-energized thermal relay(s) and K31 (warning thermal) are reset (picked) by the RESET side of the switch. The thermal relay that dropped re-establishes a hold circuit through its N/O point and the now closed high temperature thermal switch.

Since storage relay K1 (EPO control) remains energized through the power-off sequence, a power-on sequence begins when the PWR ON/OFF/RESET switch is returned to PWR ON. If the overheated area(s) has not cooled down sufficiently, the power-on sequence will not be completed. K45 (start delay) is picked by the PWR ON switch, but K2 (start sequence) cannot pick since the catastrophic thermal condition has not been reset.

Relay K53 (arm/disarm line sense) in the line sense and switching circuit picked during the power-off sequence. With K53 picked the battery backup supply is blocked from cutting in and sustaining power for an additional period of time.

CONTROLS AND INDICATORS

The following paragraphs identify and describe the controls and indicators associated with DE power and located on the SU power control panel (Figure 5-14) and on the storage power control panel (Figure 5-15).

SU Power Control Panel

Indicators

DRIVER ON (L2): Lights when the SU driver supply regulator B2A3 is on.

POWER CHECK (L3): Lights when an OV/OC condition exists in one of the SU regulators.

DC ON (L4): Lights when all ten logic supply regulators in the SU are on.

+6M (L5): Lights when a manual (+) or minus (-) voltage excursion is performed on regulator A2A3, feeding SU gates A and C.

+6M (L6): Lights when a manual plus (+) or minus (-) voltage excursion is performed on regulator A2B3 feeding SU gates B and D.

Controls

+6M (R1): Varies the +6V(M) regulator A2A3 output voltage feeding SU logic gates A and C. The DE remains available to the system.

+6M (R2): Varies the +6V(M) regulator A2B3 output voltage feeding SU logic gates B and D. The DE remains available to the system.

Storage Power Control Panel

Indicators

PWR COMPLETE (DS1): With the TEST/NORMAL switch in NORMAL, this indicator lights when all DE power supplies are on; in TEST, it lights when all element power supplies are on except SU regulator B2A3.

PWR CHECK (DS2): Is normally on and is extinguished when the power-on sequence is complete.

PS OV/OC (DS3): Lights when an OV/OC condition in a dc regulator is detected. The indicator is extinguished by depressing RESET located on the C/I, and then turning the PWR ON/OFF/RESET switch to RESET.

TEST MODE (DS4): Lights when the DE is in test mode as a result of the TEST/NORMAL switch on the DE maintenance panel being in TEST.

BTRY ON (DS5): Lights when the DE is on battery backup power as a result of losing 208V ac prime power.

MAINLINE ON (DS6): Lights when the input voltage is present beyond the load side of the input circuit breaker and no EPO/MPO condition exists.

WARNING Thermal (DS7): Lights when any of the DE thermal sensing switches detects a temperature within about 10°F of the nominal thermal protection temperature.

GATE Thermal (DS8): Lights when an overtemperature (catastrophic) condition exists in any of the three storage logic gates in frame 3 or in the four SU logic gates in frame 2. (134°F±3°F).

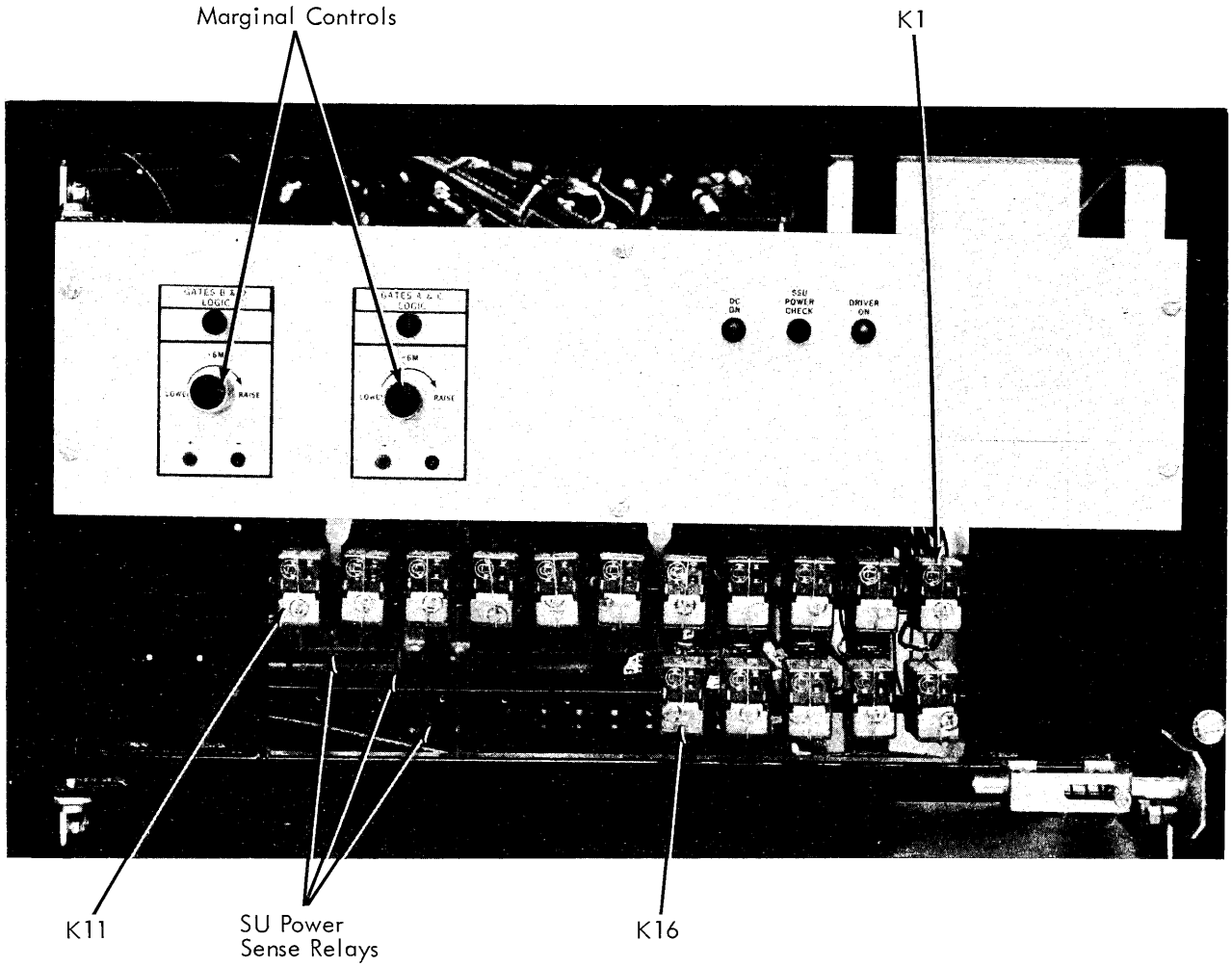


Figure 5-14. SU Power Control Panel

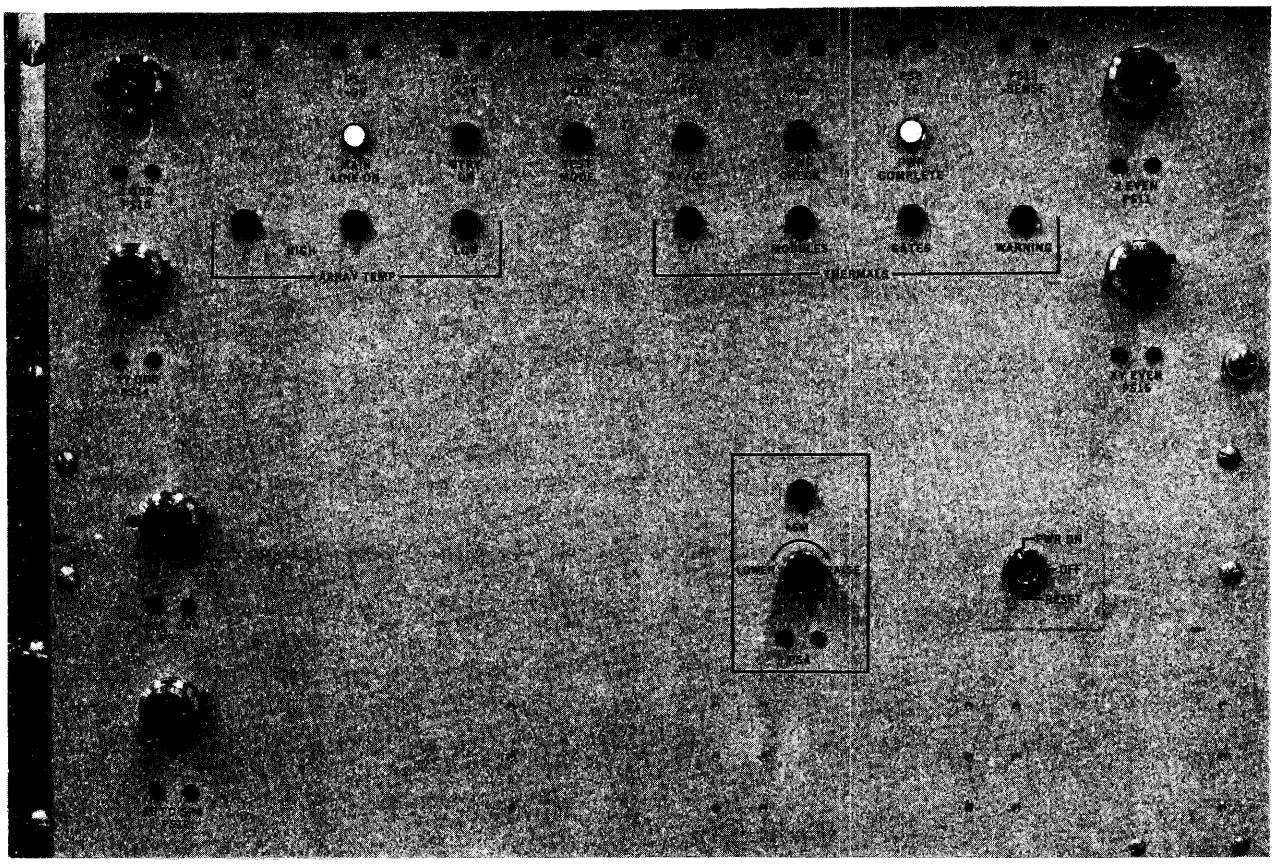


Figure 5-15. Storage Power Control Panel

MODULE THERMAL (DS9): Lights when an overtemperature (catastrophic) condition exists in either of the two storage power tubs in frame 05 or in the SU power tub in frame 01 (140°F ± 3°F).

C/I Thermals (DS10): Lights when an overtemperature (catastrophic) condition exists in the C/I (160°F±3°F).

ARRAY TEMP (DS11–DS13): Are associated with the two BSM arrays in frame 3. The three indicators signal array temperature conditions. The indicator labeled LOW (DS11) indicates any array undertemperature condition in either or both the arrays (86°F). During a normal power-on sequence, the indicator is on until both arrays are up to temperature.

Indicators A HIGH (DS13) and B HIGH (DS12) light when an overtemperature condition (catastrophic) exists in the associated array. A power-off sequence begins when one of the HIGH indicators lights (115°F).

+6M (DS14): Lights when a manual plus (+) or minus (-) voltage excursion is performed on storage regulator 4.

Controls

PWR ON/OFF/RESET (S1): Is a double-pole double-throw, lock ON, lock OFF, momentary RESET toggle switch. The PWR ON position initiates the power-on sequence for the DE. The OFF position initiates the power-off sequence provided that the TEST/NORMAL switch is in TEST, and the DE is in state zero. The RESET position performs three functions: (1) resets the thermal warning circuits, (2) resets the catastrophic thermal circuits, and (3) resets the OV/OC circuits.

Z EVEN (R1): Optimizes the output of the Z-driver (inhibit driver) regulator 11 for the even core array.

Z ODD (R2): Optimizes the output of the Z-driver (inhibit driver) regulator 10 for the odd core array.

XY EVEN (R3): Optimizes the output of the XY driver regulator 15 while performing the "shmoo" procedure for the even core array.

XY ODD (R4): Optimizes the output of the XY driver regulator 14 while performing the "shmoo" procedure for the odd core array.

+6M (R5): Controls the +6V(M) regulator 4 feeding the storage section circuitry. The DE remains available to the system.

+6K SP4 (R6): Optimizes the output of the +6K current sink supply (regulator 9) during SP4 (storage protect) core array shmooing procedures.

+6 TC SP4 (R7): Is similar to +6K SP4 but controls regulator 12.

Test Jacks

A pair of test jacks is provided on the storage power control panel for each of the 15 storage dc regulators. These jacks allow the regulator outputs to be monitored during installation or maintenance.

Test OBS Pushbutton (S2)

The TEST OBS (on-battery supply) pushbutton is on the inner rear wall of frame 5. Pressing the pushbutton picks relay K44 (sense OBS). An on-battery condition is simulated through the N/O points by forcing an OBS signal to DE logic circuitry.

TEST OTC Pushbutton (S3)

The TEST OTC (out-of-tolerance check) pushbutton is on the rear wall of frame 5. Pressing the pushbutton drops relay K43 (sense OTC). An OTC condition is simulated through the N/C points of K43 by forcing an OTC signal to DE logic circuitry.

ELEMENT MPO PULL (Master Power Off) Switch (A-A1S1)

The DE has one MPO switch, located at the upper left corner of gate A, frame 1. Pulling this switch drops all hazardous voltages outside of the prime power box, including convenience outlet voltage. The +24V dc and 28V ac control voltages remain active. Power is restored to the DE when the MPO switch, which is mechanically latched off, is reset by maintenance personnel, and the PWR ON/OFF/RESET switch is in PWR ON.

PAMs are present on the 9020D System only. All PAM components and circuits associated with power distribution and control are described in this chapter. For additional information on protection and checking (including EPO/MPO) refer to Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- All power supplies and controls are in the PAM frame.
- A maintenance panel provides monitoring and control functions.
- A large (AB) PAM has three frames:
  1. PAM frame.
  2. Cable entry frame.
  3. Adapter frame.

Figures 6-1 through 6-6 show the component locations within the PAM. The PAM has three frames: the PAM frame, the cable entry frame, and the adapter frame (Figure 6-1).

The PAM frame includes adapters (gate A), PAM common control logic (gate B), a power distribution system (gates C, E, and L), a maintenance panel, relay gate and power controls (gate D), an operator's control panel (gate F), and a cable connector panel.

The cable entry frame provides entry space for cables between the PAM and other system elements and peripheral devices.

The adapter frame provides four hinged gates (G, H, J, and K) for packaging additional adapters.

Two configurations of PAM can be used, depending on the size of the 9020 System and the number of attached I/O devices. The small PAM includes only the PAM and cable entry frames (logic gates A, B, and D). The large PAM includes all three frames (logic gates A, B, D, G, H, J, and K). The number of logic gates and types of adapters affect the kind and number of power regulators that are installed within the PAM.

Components in the power area include:

1. Circuit breakers, fuses, switches, contractors, and relays for power sequencing and distribution.
2. A combination of +24V dc and 28V ac power supply.
3. A 75-ampere converter/inverter (C/I).
4. A variety of dc regulators that supply normal and/or special voltages to adapter circuits and devices.
5. Temperature thermals, overvoltage/overcurrent circuitry, and undervoltage protection circuitry.
6. A marginal voltage select switch, meter, potentiometer, and indicators associated with +6V dc marginal supplies.
7. Switches and pushbuttons to place the PAM in test status, to reset a thermal condition, and to simulate an OTC condition. Switches and jacks are also available for adapter testing.

The PAM operator's control panel includes:

1. An element master power off (MPO) pull switch for immediately removing all power from the PAM.
2. A POWER ON/OFF switch that is used for normal power on/off sequences.
3. Indicators for visual determination of mainline power, power sequence complete, and power check conditions. Four indicators also reflect the operational state of the PAM.

Power Interlock Circuitry

- Each PAM is power-interlocked with the System Console.
- All main power is removed from PAM under EPO/MPO conditions.

Power interlocking is such that all main PAM power can be removed under EPO/MPO conditions. Pulling the EPO switch on the System Console (SC) removes power from all elements: pulling the PAM MPO switch removes power from only that PAM.

Figure 6-7 shows the PAM power interlock circuitry. Under normal or EPO/MPO power-off conditions, a +24V dc service voltage is still available between all elements and the SC. With the EPO switch closed at the SC, the PAM (or any element) can pick and hold EPO contactor K37. In the PAM, this circuit is from the +24V dc source, through an isolation diode, to the SC, through the EPO switches and K37 relay coil, and to the common 24V dc return path.

The K37 N/O points in the SC provide the pick circuit for the EPO contactor in the PAM. This circuit is through the MPO switch and EPO contactor K2, to the SC, through the K37 N/O contacts, and to the common 24V dc return path.

Three of the four main sets of K2 points gate 3-phase power into the main power area; the fourth set of points gates +24V dc into the power sequence and control area. Further operation within these areas also depends on the setting of the POWER ON/OFF switches as described later.

When the 24V is applied to the control circuitry, an auxiliary EPO relay (K44), is picked. This auxiliary relay is, in effect, parallel with K2 and controls the 28V ac power into the C/U (Figure 6-8).

AC Distribution

- 208V, 3-phase, 60-HZ input power.
- Under normal power-off conditions, ac power is available to:
  1. The 115V ac convenience outlets.
  2. The 24V dc/28V ac power supply L-PS1.
  3. The 28V ac C/I control circuitry.
- Under EPO/MPO conditions, only +24V dc exists outside the prime power area.

AC input includes 3-phase, 208V, 60-HZ power that is routed directly from the customer's ac service outlet (Figure 6-8).

Turning on mainline breaker CB1 applies 208V ac, single-phase power to the 24V dc/28V ac power supply (PS1). As described in the preceding section, the +24V dc control voltage is routed first to the SC, EPO circuitry. If the EPO switch is closed, K37 (in the SC) picks, if not already picked by another element, and provides a return circuit for PAM EPO contactor K2. If the PAM EPO switch is closed, +24V dc is applied to the other leg of relay K2, causing it to pick.

From the three main sets of K2 contactors (Figure 6-8); 208V ac, single-phase power is routed via CB2 to step-down transformer T1 which provides 115V ac to the convenience outlets.

The fourth set of K2 contacts gates +24V dc into the power sequence and control circuitry. This voltage immediately turns on the MAINLINE POWER indicator and picks K44 (auxiliary EPO). The K44 points act as an extension for K2 and gate the 28V ac into the C/I circuitry.

Under normal power-off conditions, power is available to the following PAM circuitry:

1. 115V ac convenience outlets.
2. 28V ac to the C/I control circuitry.
3. +24V dc to the power sequence and control circuitry.
4. +24V dc to the EPO/MPO circuitry.

Note: Under EPO/MPO conditions, power is still available at the +24V dc power transformer, and 24V dc is still active in the power interlock cable to the SC. This 24V is needed to return power to the system elements when the EPO/MPO condition is removed. All power can be removed from the PAM by opening CB1 or the main customer service outlet.

Before further distribution of 208V ac can occur, contractor K3 must be picked. The pick of K3 is a part of the power-on sequence, described in a later section. When K3 is picked, power is supplied to all logic gate and power supply blowers and to the C/I. The C/I supplies a 2500-HZ square wave to the various dc regulator supplies.

DC Distribution

- The number of regulators and their dc voltage depends on the size of the PAM and attached I/O devices.
- 2500-HZ primary input to all regulators.
- All regulator supplies are relay-sensed.
- Standard dc bus distribution.

All dc voltages, except the +24V and +25V power sequence and control voltages, are obtained from regulators. The number of regulators, and in some cases their output rating, depends on the size of the PAM and the type of attached I/O devices.

Input power to these regulators is from the C/I as 2500-HZ, 137V (rms) square wave (Figures 6-8 and 6-9). Application of the input is such that the regulator voltages sequence up in five groups.

Each regulator is monitored by a sense relay which controls the proper power on and off sequencing in the PAM. Outputs of the dc regulators are distributed to the PAM logic gates by standard dc bus distribution. Table 6-1 lists the various regulators with their voltage and current ratings, sense relays, and gates to which power is supplied.

Special dc voltages such as the -48V and +48V are required for the Teletype* and 1052 printers, respectively. The -48V power supply (PSA2) is supplied to DC2-A01 of the Teletype relay section. The +48V supply (PSB2) is applied to I/O connectors S4-R1-4, S4-R2-4, S4-S2-4, S4-S2-4, and S4-S4-4. These connectors supply power to the 1052 on the SC and to remote 1052's.

Note: When two PAMs are connected to a common 1052, a jumper wire is connected between the +48V dc output of each PAM. Therefore, +48V dc is present at the output of the PAM that has been turned off.

*Trademark of Teletype Corporation

Table 6-1. PAM Regulator Ratings, Distribution, and Sensing

Regulator	Nominal Voltage	Ampere Rating	Logic Gate	Terminal Board	Sense Relay
PSA2	-48	2	--	DC2-A01 TTY Relay Section	K41
PSA3	-3	20	A	A-TB2-10, A-TB1-10	K24
			B	B-TB2-10, B-TB1-10	
PSA4	-12	7	A	A-TB2-4, A-TB1-4	K13
			G	G-TB2-4, G-TB1-4	
PSA5	+6	40	A	A-TB1-8, A-TB2-8	K72
PSA6	+3	40	A	A-TB1-12, A-TB2-12	K12
PSA7	+3	40	G	G-TB1-8, G-TB2-8	K62
PSB2	+48	2/20	--	S4 Cable Section to 1052 Printers	K51
PSB5	+6	40	B	B-TB1-12, B-TB2-12	K31 K-31
PSB6	+3	40	B	B-TB1-8, B-TB2-8	K22
PSB7	+3	40	H	H-TB1-12, H-TB2-12	K52
PSC2*	+18	11	A	A-TB1-2, A-TB2-2	K71
PSC4	+12	7	A	A-TB2-2, A-TB1-2	K15
			G	G-TB2-2, G-TB1-2	
PSC5	+6	40	J	J-TB1-12, J-TB2-12	K63
PSC6	+6	40	H	H-TB1-8, H-TB2-8	K73
PSC7	+3	40	J	J-TB1-8, J-TB2-8	K42
PSD2	+6	40	A	A-TB1-6, A-TB2-6	K54
	(Special)		B	B-TB2-6	
			G	G-TB1-6, G-TB2-6	
			H	H-TB1-6, H-TB2-6	
			J	J-TB1-6, J-TB2-6	
			K	K-TB1-6, K-TB2-6	
PSD3	-3	20	G	G-TB1-10, G-TB2-10	K34
			H	H-TB1-10, H-TB2-10	
PSD4	-3	20	J	J-TB1-10, J-TB2-10	K14
			K	K-TB1-10, K-TB2-10	
PSD5	+6	40	K	K-TB1-8, K-TB2-8	K53
PSD6	+6	40	G	G-TB1-12, G-TB2-12	K74
PSD7	+3	40	K	K-TB1-12, K-TB2-12	K32

*Buffer processor feature only.

Power-On Sequence

- DC voltages sequence up in five groups.

Refer to Figures 6-10 and 6-11. Before the power-on sequence can begin in the PAM, CB1 must be closed. Also, system EPO contactor K37 in the SC and element EPO contactors K2 and K44 in the PAM must be energized. Under these initial conditions and before the power-on sequence is started, the following circuit conditions must exist:

1. The MAINLINE POWER indicator is on at the operator's control panel.
2. The POWER CHECK indicator on the maintenance panel and control panel are on through the K25 N/C points to indicate that a power-off situation exists. A 'power check' signal is also sent to the SC to turn on an indicator at that operator's console.
3. With all thermal elements in their N/C position, relay K55 (overtemperature) picks through the K1 N/C points and relay K45 (marginal temperature) picks through the K25 N/C and K1 N/C points in series. Both relays establish hold circuits through their N/O points and remain picked until the temperature within the PAM rises to a level that will open one or both circuits. The pick of these two relays is fast enough so that the THERMAL CHECK indicator on the maintenance panel appears to remain off.

The power-on sequence can now be started by closing the POWER ON/OFF switches on the maintenance panel and the operator's control panel. With both switches closed, relay K1 (power-on delay) and K8 (power-on test TD) start their time delay cycle.

K1 (power-on delay) is adjustable between 5 and 30 seconds and is set to stagger the power-on sequence of the entire 9020 system. This delay must, however, be a minimum of 5 seconds to allow the C/I bias voltage time to react before main power is applied.

K8 (power-on test TD) is adjusted to time out after the PAM power-on sequence has been completed. Therefore, a realistic setting for the K8 delay should be approximately 5 seconds longer than the setting for K1 (power-on delay). Note that these two relays use the +25V dc from the C/I. This filtered supply provides more reliable operation of time delay relays than the unfiltered +24V supply.

After K1 (power-on delay) has timed out, its points transfer to complete a circuit for K75 and K64 (sequence power on/off). This circuit includes the K1 N/O, K55 N/O, K35 N/C, and K1-5 N/C points within the C/I. With contactor K1 dropped in the C/I, a starting resistance is in series with the 208V ac input. This resistance limits the initial power surge and prevents possible damage to the C/I diodes. If, for some reason, the K1 contactor is not dropped when power is turned on, the pick circuit cannot be completed, and power cannot be sequenced on until the trouble is corrected. When power comes up, K1 picks and

K1-5 points open. At this time, however, a hold circuit has been established by the K64 N/O points in parallel with the K1-5 points.

When K75 (sequence power on/off) picks, the K75 N/O points provide a pick circuit for contractor K3 (sequence 1). Contactor K3 now gates 208V ac, single-phase and 3-phase power to the various gate blowers, and 208V ac, 3-phase power to C/I (Figure 6-8).

The 2500-Hz output from the C/I is fed directly into PSA 3 (a -3V dc regulator) and PSA4 (a -12V dc regulator). The PSA3 supply provides the -3V to gates A and B which contain the system interface circuits. When this voltage is applied first, "noise" is prevented from causing system problems during the power-on sequence. When the PSA3 output voltage has reached its operating level, K24 (PSA3 sense) picks to indicate that this initial sequence is complete.

Contactor K7 (sequence 2) now picks through the K24 N/O and K75 N/O points. The K7 points gate C/I power into PSB5 (a +6V dc regulator). This supply is fed to the B-gate to further condition the interface drivers and terminators. When the PSB5 output voltage has reached its operating level, K31 (PSB5 sense) picks to indicate that sequence 2 is complete.

Contactor K5 (sequence 3) now picks through the K31 N/O, K24 N/O, and K75 N/O points. Two sets of K5 points gate C/I power into the eight +3V dc and -3V dc regulator supplies. When these regulator outputs reach operating level, their corresponding sense relays pick:

+3 Volts		-3 Volts	
K12	(PSA6)	K14	(PSD4)
K22	(PSB6)	K34	(PSD3)
K32	(PSD7)		
K42	(PSC7)		
K52	(PSB7)		
K62	(PSA7)		

When these eight sense relays have picked, the third sequence is complete and a series circuit is completed to pick contactor K6 (sequence 4). The K6-series pick circuit includes the K75 N/O points in addition to the N/O points for the preceding eight relays. Two sets of K6 points gate C/I power to five +6V dc regulator supplies. When these regulator supplies reach operating level, their corresponding sense relays pick:

+6 Volts	
K53	(PSD5)
K63	(PSC5)
K72	(PSA5)
K73	(PSC6)
K74	(PSD6)

When these five sense relays have picked, the fourth sequence is complete and the last sequence can begin. Contactor K4 (sequence 5) picks through the series circuit which includes K75 N/O in addition to the N/O points of the previous five sense relays. When these regulator supplies reach operating level, their corresponding sense relays pick:

Sense Relay		Voltage
K13	(PSA4)	-12
K41	(PSA2)	-48
K51	(PSB2)	+48
K54	(PSD2)	+6
K71	(PSC2)*	+18
K15	(PSC4)	+12

*Buffer processor feature only.

When these last six sense relays have picked, a series circuit is complete through their N/O points to pick K21 and K25 (sequence complete). When K21 and K25 are picked, a hold circuit is established through the K72 N/O and K21 N/O points until either a normal power-off sequence is started or a power fault occurs.

When the K25 points transfer, the two POWER CHECK indicators are turned off with the N/C circuit, and the POWER SEQUENCE COMPLETE indicators are turned on with the N/O circuit. With the K25 points closed, a 'power-on' reset is provided to the PAM logic circuitry.

Shortly after the power sequence is complete, K8 (power-on test TD) should time out. When the K8 points transfer, a test is made for sequence complete. If K21 (sequence complete) has not picked, a path through K8 N/O and K21 N/C picks K35 (power fault) and power is sequenced off. This sequence is described in a later section.

After power comes up, the PAM is in operational state zero. If the TEST switch on the maintenance panel is off, relay K61 (power interlock) picks through logic circuitry. The K61 N/O and K25 N/O points form a parallel path which electrically disables the POWER ON/OFF switches and maintains a hold circuit for K1 (power-on delay) and K8 (power-on test TD). If the executive control (EXC) program configures the PAM out of state zero, power cannot be removed (except under EPO/MPO conditions) without requesting a reconfiguration back to state zero. With the PAM in state zero and with the TEST switch on, K61 drops and the POWER ON/OFF switches are effective.

Normal Power-Off Sequence

- DC voltage sequence off in five groups.

Refer to Figures 6-10 and 6-12. To initiate a power-off sequence, the PAM must be in operational state zero and the TEST switch on the maintenance panel must be set to TEST. These two conditions allow relay K61 (power interlock) to drop through logic circuitry and to open the hold circuit in parallel with the POWER ON/OFF switches.

When either the maintenance panel or control panel POWER ON/OFF switch is set to OFF, K1 (power-on

delay) and K8 (power-on test TD) drop. The K1 N/O points drop K64 and k75 (sequence power on/off) to start the power-off sequence with the sequence 5 voltage group.

Dropping relay K75 immediately opens the pick (and hold) circuit for contactor K4 (sequence 5), and input power is removed from the four sequence 5 supplies (Figures 6-8 and 6-9). When the first of these four corresponding sense relays drops, the circuit for K21 and K25 (sequence complete) is opened. This action turns off the POWER SEQUENCE COMPLETE indicators on the maintenance panel and control panel and turns on the POWER CHECK indicator. A 'power check' signal is also sent to the SC to turn on the POWER CHECK indicator on that control panel.

After the four sequence 5 sense relays have dropped, their N/O points in parallel open the circuit for contactor K6 (sequence 4) and input power is removed from the five +6V regulator supplies.

After the five sequence 4 sense relays have dropped, their N/O points in parallel open the circuit to K5 (sequence 3) and input power is removed from the eight +3V and -3V regulator supplies.

The last three power sequences do not occur as precisely as the first two. When K22 (PSB6 sense) drops, +3V dc has been removed from gate B circuitry. The K22 N/O points, therefore, open the circuit for contactor K7 (sequence 2), and power is removed from the +6V regulator which supplies the +6V dc to gate B. This sequencing control minimizes electrical noise on the system interface lines during the power-off sequence.

When K22 dropped, the remaining sense relays concerned with sequence 3 also dropped. After these eight relays have dropped, their N/O points in parallel open the circuit for K3 (sequence 1) and input power is removed from the C/I and gate blowers. With the C/I turned off, power is removed from the last power supply (PSA3) and the power-off sequence is complete.

All dc voltages have now been removed from the PAM, except 24V dc to the PAM power sequence and control circuitry and 24V dc to the power interlock (EPO/MPO) circuitry which interconnects with the SC.

Existing ac input includes power to the convenience outlets and 28V ac to the C/I.

Emergency Power-Off Sequence

- EPO/MPO conditions immediately remove all power, except the +24V dc power interlock voltage.
- Normal power-off sequencing is bypassed.

If either the system EPO or the PAM MPO pull switch is pulled, all power is turned off beyond the entry terminals, except the +24V dc supply. These EPO/MPO switches are mechanical interlock-type switches that must be reset manually.

Pulling either the EPO or MPO switch causes contactor K2 (EPO) to drop in the PAM. The K2 points immediately remove all ac power to the blowers, C/I and convenience outlets, and all +24V dc to the power sequence and control circuitry (Figure 6-8). With all power removed, normal power-off sequencing cannot occur and all dc regulator power falls simultaneously.

Note that under EPO/MPO conditions +24V dc is still within the power interlock cable that connects the PAM and SC. This voltage is necessary so that power can automatically sequence up when the EPO/MPO condition is removed.

Special Power-Off Sequence

Regulator Undervoltage Power-Off Sequence

- Each regulator output has a sense relay.
- Undervoltage conditions automatically sequence power off.
- Power does not sequence up until POWER ON/OFF switch is set to OFF and then ON.

Each PAM regulator (Figure 6-9) has an output sense relay which ensures that the associated regulator output is at its proper amplitude.

When K25 (sequence complete) picks after the power-on sequence has been completed, a K25 N/O point establishes a test circuit for each sense relay (Figure 6-10). If any sense relay drops, its corresponding N/O points complete a circuit to pick K35 (power fault). Relay K35 establishes a hold circuit through its N/O points, K55 N/O, and K1 N/O.

A power-off sequence is started when the K35 N/C points cause K64 and K75 (sequence power on/off) to drop. The K75 points cause as much of a normal power-off sequence as is possible, depending on which one of the regulator supplies has failed.

For example, if any of the sequence 5 sense relays drops (K41, K51, K54, or K71), a normal power-off sequence occurs, starting with the drop of K4 (sequence 5).

If any of the sequence 4 sense relays drops (K53, K63, K72, K73, or K74), a normal power-off sequence also occurs, starting with the drop of K4 (sequence 5). In this case, the K4 circuit opens because of the N/O sense relay contact instead of waiting for K75 (sequence power on/off) to drop.

If, however, any of the sequence 3 (+3V or -3V) sense relays drops (K12, K14, K22, K32, K34, K42, K52, or

K62), a normal power-off sequence is bypassed in the initial phase. The +6V supplies of sequence 4 are dropped immediately to avoid circuit damage. The remaining sequence 3 supplies remain on until all sequence 4 sense relays have dropped and normal power-off sequence continues from that point.

After power has sequenced off, K1 (power-on delay) remains picked because the POWER ON/OFF switches are still set to ON. The K1 N/O points maintian the hold circuit for K35 (power fault), which prevents the repick of K75 (sequence power on/off).

To restore power, a POWER ON/OFF switch must be set to OFF and then ON. This procedure drops K1 and K35 when the switch is turned off and starts the normal 5 to 30 second power-on delay when the switch is returned to ON. This 5-second minimum period allows the regulator bias voltage to take effect before full input power is applied.

Overvoltage/Overcurrent Power-Off Sequence

- Each regulator has an OV/OC sense relay.
- An OV/OC condition automatically sequence power off.
- Power does not sequence on until the regulator is reset and the POWER ON/OFF switch is set to OFF and then ON.

Each PAM regulator has an OV/OC sense relay. If an OV/OC condition occurs in a given regulator, its respective sense relay (a reed relay on the OV/OC SMS card) is picked. The N/O contacts of any of the picked sense relays (Figure 6-10) picks K35 (power fault) directly. K35 establishes a hold circuit through its N/O points, K55 N/O, and K1 N/O.

A normal power-off sequence is started when the K35 N/C points cause K64 and K75 (sequence power on/off) to drop. After power has sequenced off, K1 (power-on delay) remains picked because the POWER ON/OFF switch is still set to ON.

To restore power to the PAM, the OV/OC condition must be reset manually at the C/I and the POWER ON/OFF switch must be set to OFF and then ON.

Pressing RESET pushbutton at the C/I drops the OV/OC reed relay at the regulator. The RR N/O points open the initial pick (and hold) circuit for K35 (power fault). When the POWER ON/OFF switch is set to OFF, K1 (power-on delay) drops and breaks the hold circuit for K35. When the POWER ON/OFF switch is set to ON again, K1 picks and starts a normal power-on sequence.

If the OV/OC condition is not reset before the POWER ON/OFF switch is operated, K35 continues to hold through the RR N/O points. Therefore, K75 (sequence power on/off) cannot repick with K1, and power is not sequenced up.

Note: When RESET is pressed at the C/I, hold the RESET pushbutton for a few seconds. A momentary depression is not enough time to reset the OV/OC reed relay and gives a false impression of a second OV/OC condition.

Thermal Check Power-Off Sequence

- A marginal temperature condition does not sequence power off.
- An overtemperature condition immediately sequences power off.
- Power does not sequence up until the high thermals are reset and the POWER ON/OFF switch is turned off and then on.

Two thermal checks (marginal temperature and overtemperature) can occur in the PAM. The first check (marginal temperature) occurs when the PAM operating temperature in any of the logic gates is between 120° and 130°F or the temperature in the power tub is between 130° and 140°F. When any of these thermal devices opens K45 (marginal temperature) drops and turns on the THERMAL CHECK indicator on the maintenance panel. This marginal condition does not turn on the POWER CHECK indicator at the PAM but turns on the POWER CHECK indicator at the System Console.

A set of K45 N/C points also sends an 'out of tolerance check' (OTC) signal to the PAM logic to set bit 6 of sense register 3. This setting causes an attention interrupt to the IOCE so that the EXC program can be notified of the OTC condition. Note that a marginal temperature condition does not initiate a power-off sequence.

The second check (overtemperature) occurs when the operating temperature in the logic gates exceeds 130°F or when the operating temperature in the power tubs exceeds 140°F. When any of these thermal devices opens, K55 (overtemperature) drops and begins a power-off sequence by opening the circuit to K64 and K75 (power sequence on/off). When this overtemperature condition occurs, the EXC program has probably already reconfigured this PAM into state zero and out of the ATC system.

To restore power to the PAM, the thermal condition must be reset and the POWER ON/OFF switch must be turned off and then on. A THERMAL RESET pushbutton is provided to reset the thermal relays. When THERMAL RESET is pressed after the temperature in the overheated unit(s) has fallen below the warning level, the associated thermal relay picks which turns off the THERMAL CHECK indicator.

If the thermal condition is not reset before operating the POWER ON/OFF switch, power does not sequence up

because the K55 N/O points are preventing the pick of K75 (power sequence on/off). When K8 (power-on test TD) times out, however, the K8 N/O points pick and hold K35 (power fault). Relay K35 performs no logic in this case but picks because of existing circuitry.

Sequence Test Power-Off Sequence

- Power is automatically sequenced off if all voltages are not completely sequenced up within a specific time.

Power on the PAM should completely sequence up within about 10 seconds. If, for some reason, one or more of the regulators fail to operate, power is automatically sequenced off. This automatic power-off sequence is accomplished by K8 (power-on test TD), which is set for a time delay slightly longer than the time necessary to sequence power up completely. K8 picks at the end of its preset time delay.

If power has not sequenced up, K21 (sequence complete) is not picked when K8 times out. Under these conditions, K35 (power fault) picks through the K8 N/C and K21 N/C points. The K35 N/C points break the circuit to K75 (sequence power on/off) and a normal power-off sequence is started.

To start another power-on sequence, the POWER ON/OFF switch must be turned off and then on. This procedure breaks the hold circuits for K35 and allows K75 to be repicked.

CONTROLS AND INDICATORS

The controls and indicators described below are associated with PAM power and are on the operator's control panel and the maintenance panel. Both panels are described separately. The marginal check panel and the power control box are also described.

Operator's Control Panel

ELEMENT MPO PULL Switch

Pulling the ELEMENT MPO PULL switch removes (within 2 seconds) all PAM power, except primary ac input and the +24V dc EPO voltage.

Note: The ELEMENT MPO PULL switch is a mechanical latch-type switch that must be reset manually. Power is automatically sequenced on when the switch is reset if the PAM POWER ON/OFF switch is on.

POWER ON/OFF Switch

The POWER ON/OFF switch begins the power-on/off sequence in the PAM. After the completion of a power-on sequence, this switch is effective only when the PAM is in state zero and the TEST switch (on the maintenance panel) is set to TEST. This POWER ON/OFF switch is connected in series with the POWER ON/OFF switch on the maintenance panel.

MAINLINE POWER Indicator

The MAINLINE POWER indicator is on when ac power is available to the PAM and CB1 is on. This indicator is independent of the POWER ON/OFF switch operation.

POWER SEQUENCE COMPLETE Indicator

The POWER SEQUENCE COMPLETE indicator is on when the power sequence of the PAM is complete. This indicator is turned off when the first power supply is sequenced off during a power-off operation.

POWER CHECK Indicator

The POWER CHECK indicator is on when one or more of the following conditions exist in the PAM power system:

1. A catastrophic power failure has occurred (OV/OC, undervoltage, or sequence test condition).
2. An overtemperature condition has sequenced power off.
3. A normal power-off operation has occurred.

STATE Indicators

The four STATE indicators reflect the operational state of the PAM. The PAM must be in state zero (state zero indicator on) before a normal power-off sequence can be started.

Maintenance Panel

POWER ON/OFF Switch

The POWER ON/OFF switch begins the power on/off sequence for the PAM. After the completion of a power-on sequence, this switch is effective only when the PAM is in state zero and the TEST switch is set to TEST. This

POWER ON/OFF switch is connected in series with the POWER ON/OFF switch on the operator's panel.

SEQ COMP Indicator

The SEQ COMP indicator is on when the power sequence of the PAM is complete. This indicator is turned off when the first power supply is sequenced off during a power-off operation.

POWER CHECK Indicator

The POWER CHECK indicator is on when one or more of the following conditions exist in the PAM power system:

1. A catastrophic power failure has occurred (OV/OC, undervoltage, or sequence test condition).
2. An overtemperature condition has sequenced power off.
3. A normal power-off operation has occurred.

THERMAL CHECK Indicator

The THERMAL CHECK indicator is on when the PAM operating temperature has exceeded 120°F in the logic gates or 130°F in the power tub. This indicator can be turned off by pressing THERMAL RESET or by operating the POWER ON/OFF switch.

OTC Indicator (Sense Byte 3)

The OTC indicator is used during a marginal temperature condition and is on when bit 6 is set in sense register byte 3. The bit can be set by either a marginal temperature condition or by pressing OTC TEST on the power section of the maintenance panel. The OTC indicator is usually reset when an attention interrupt occurs within the IOCE.

THERMAL RESET Pushbutton

Pressing THERMAL RESET resets the thermal relays that are controlled by the thermal sensing devices and turns off the THERMAL CHECK indicator if the PAM operating temperature is below the marginal temperature.

OTC TEST Pushbutton

Pressing OTC TEST simulates an OTC (marginal temperature) condition by turning on bit 6 of byte 3 in the PAM sense register. This bit causes an attention interrupt to the EXC program where the monitor program can test the condition.

TEST Switch

The TEST switch is effective when the PAM is in state zero. This switch must be set to TEST before manual switches are effective and before a normal power-off sequence can be started.

TEST Indicator

The TEST indicator is on when the TEST switch is set to TEST. At this time, manual controls are effective.

+6M Adjustment Controls

The six +6M adjustment controls vary the selected +6V dc power supply (as selected by the MARGINAL VOLTAGE SELECT switch on the marginal check panel). The indicator above each knob is on when the selected power supply is not at its nominal value.

Calibrate Jacks

The six calibrate jacks, just below the +6M adjustment controls, are used to connect an external voltmeter for calibration of the PAM voltmeter on the marginal check panel.

Marginal Check Panel

Voltmeter

The voltmeter monitors the +6M power supply associated with the selected logic gate (MARGINAL VOLTAGE SELECT switch).

MARGINAL VOLTAGE SELECT Switch

The MARGINAL VOLTAGE SELECT switch selects the +6M power supply associated with the logic gates. This switch is normally used with the +6M adjustment controls.

Power Control Box

Circuit Breakers

CB1 (Mainline) controls the 3-phase 208V ac, 60-HZ input to the PAM from the customer's service outlet.

CB2 (Thermal CB) controls input to the convenience outlet transformer. The thermal element allows initial surges to occur without tripping. This thermal element replaces fuses F1 and F8 (Figure 6-5).

Fuses

F2–F5, F7, and F10: protect the gate and power tub blowers.

F6 and F9: protect PS1 (24V dc/28V ac) power supply.

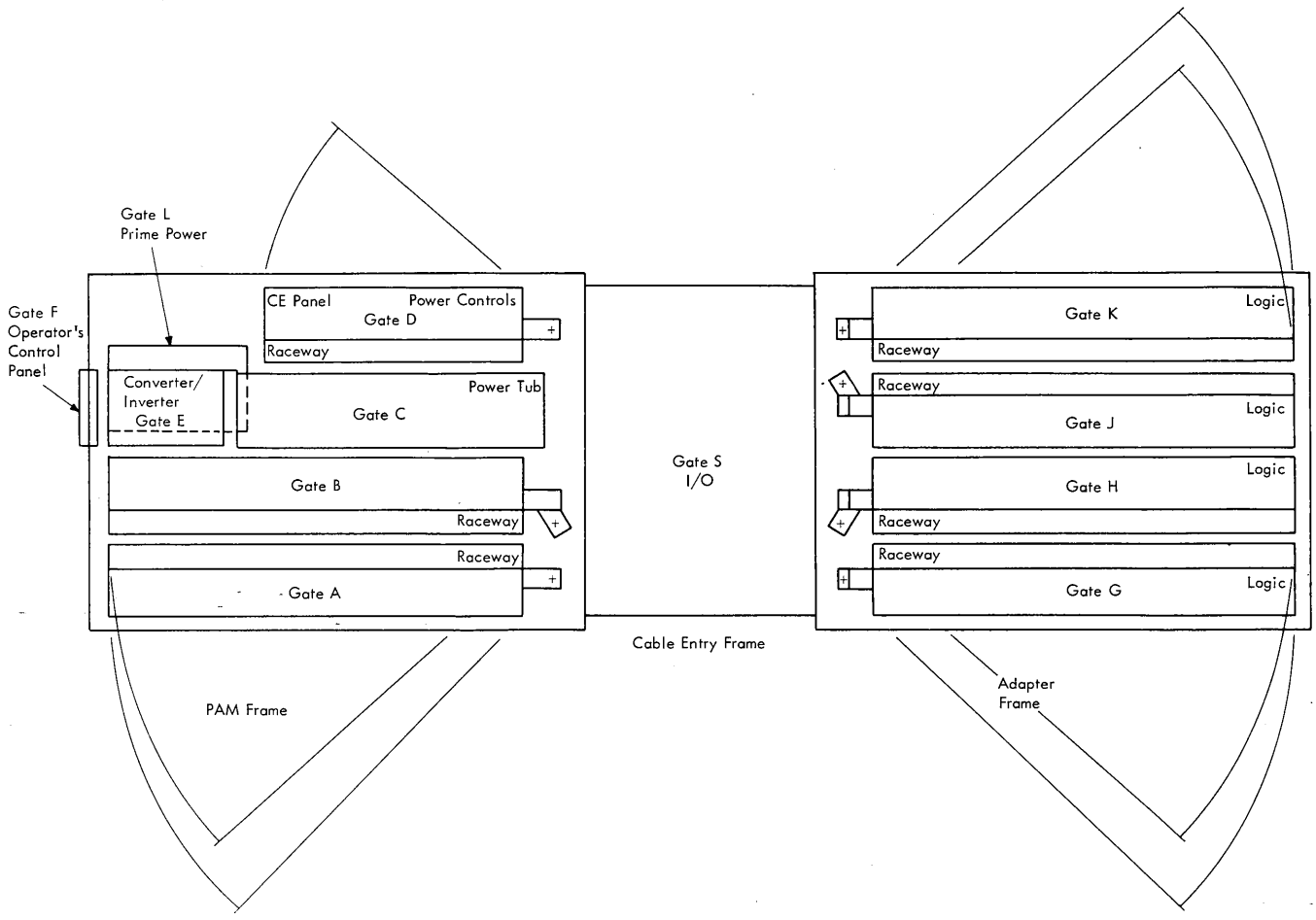


Figure 6-1. PAM Frame Identifications

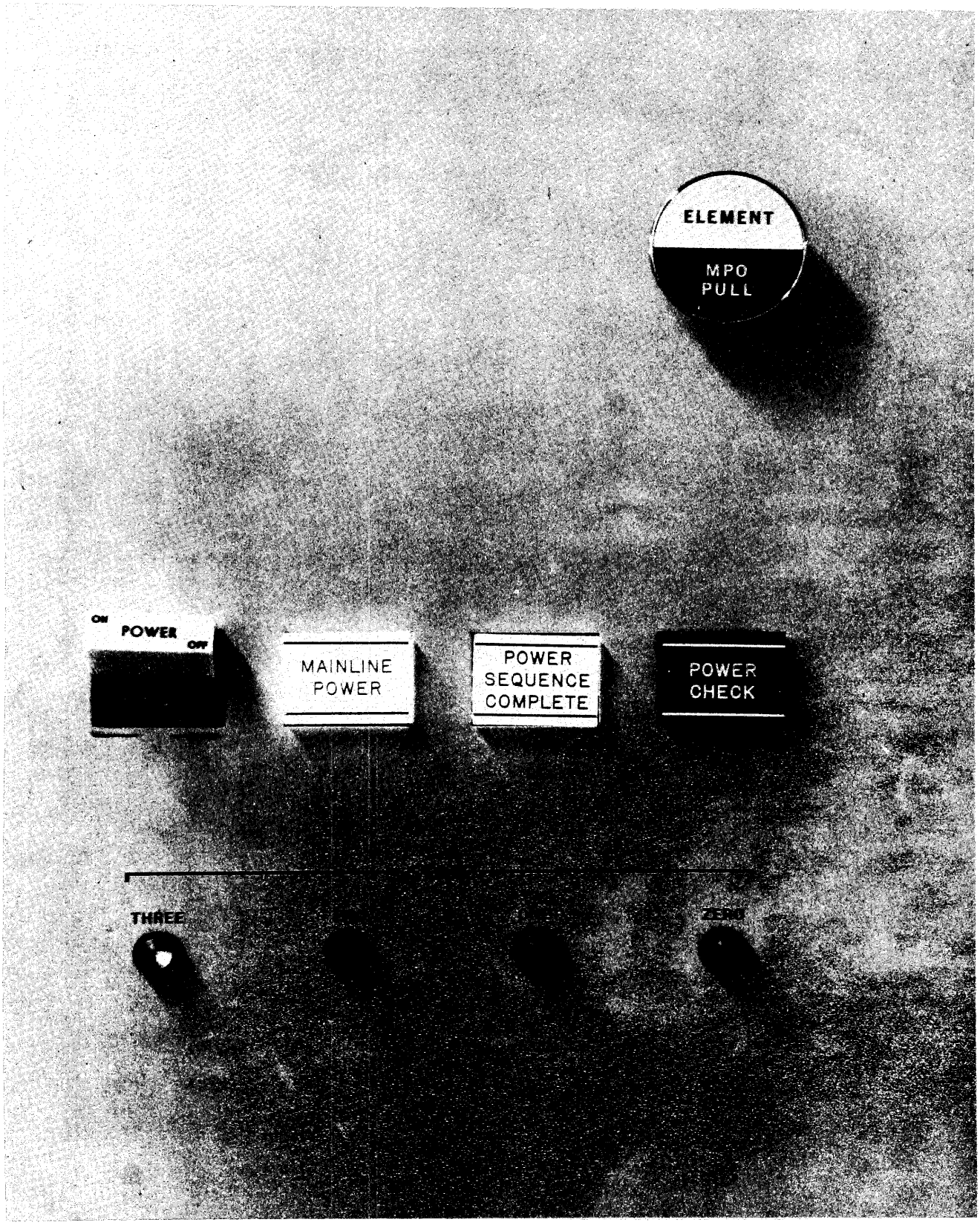


Figure 6-2. PAM Control Panel

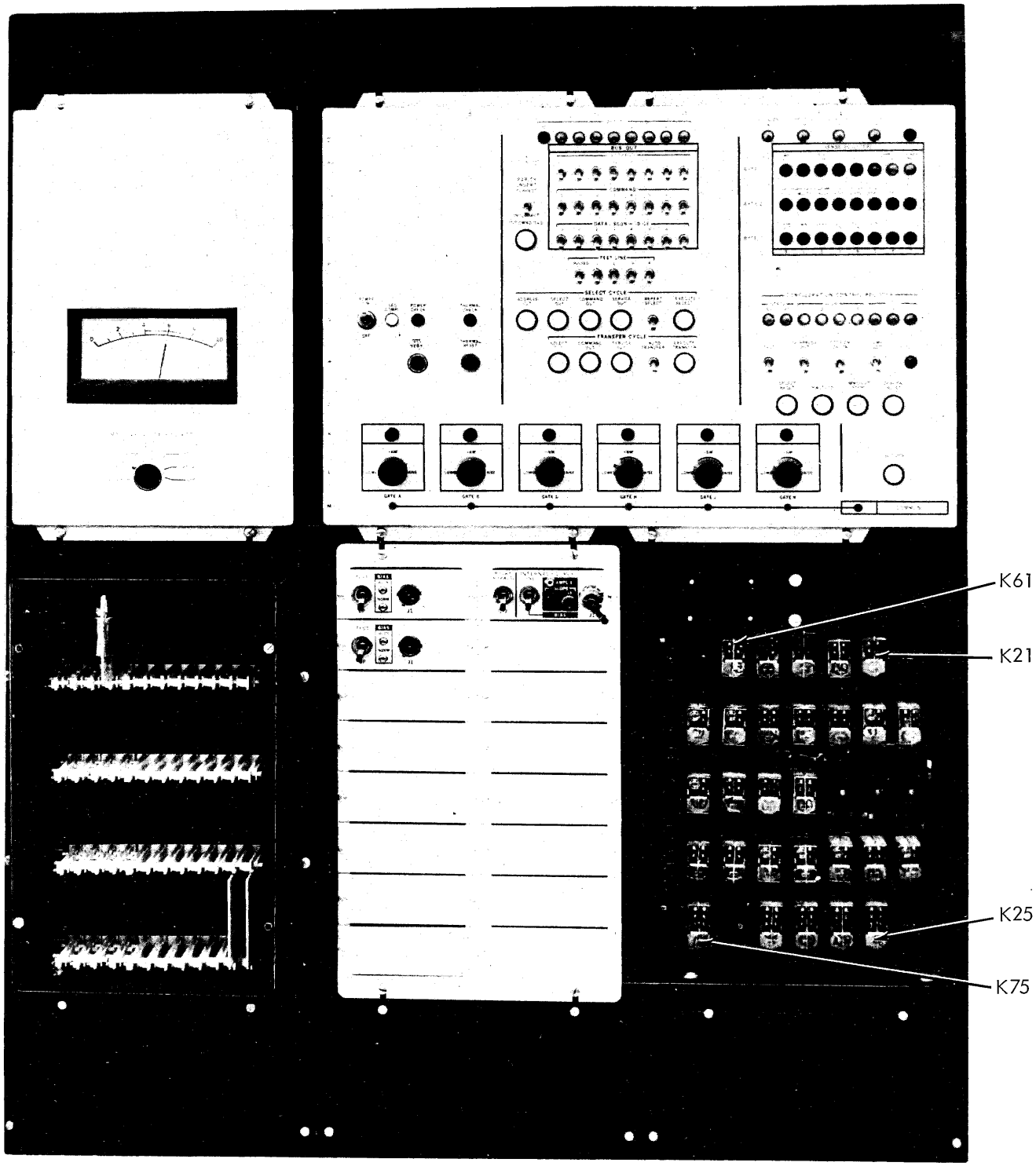


Figure 6-3. PAM Maintenance Panel

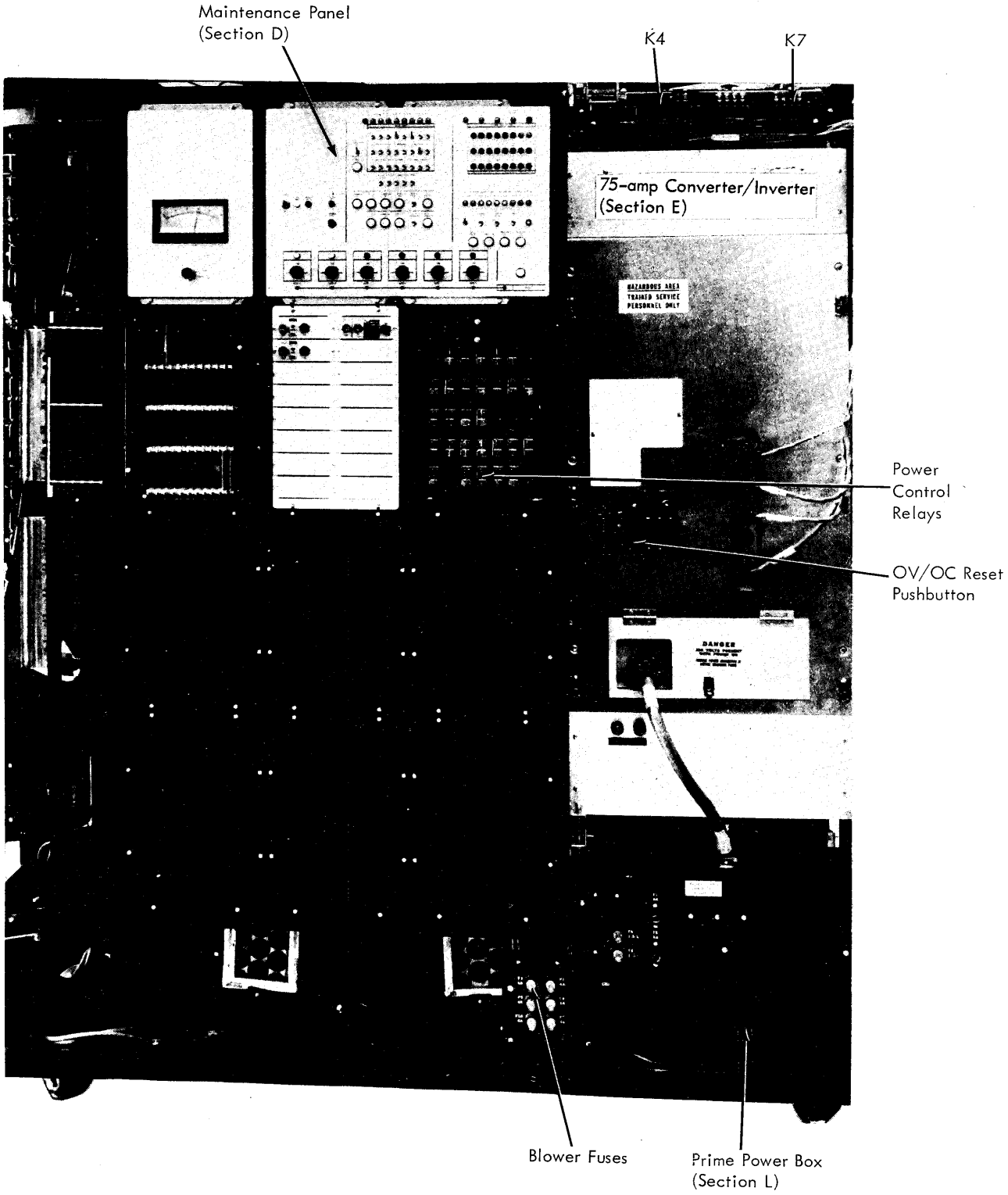


Figure 6-4. PAM Maintenance Panel and Power Controls

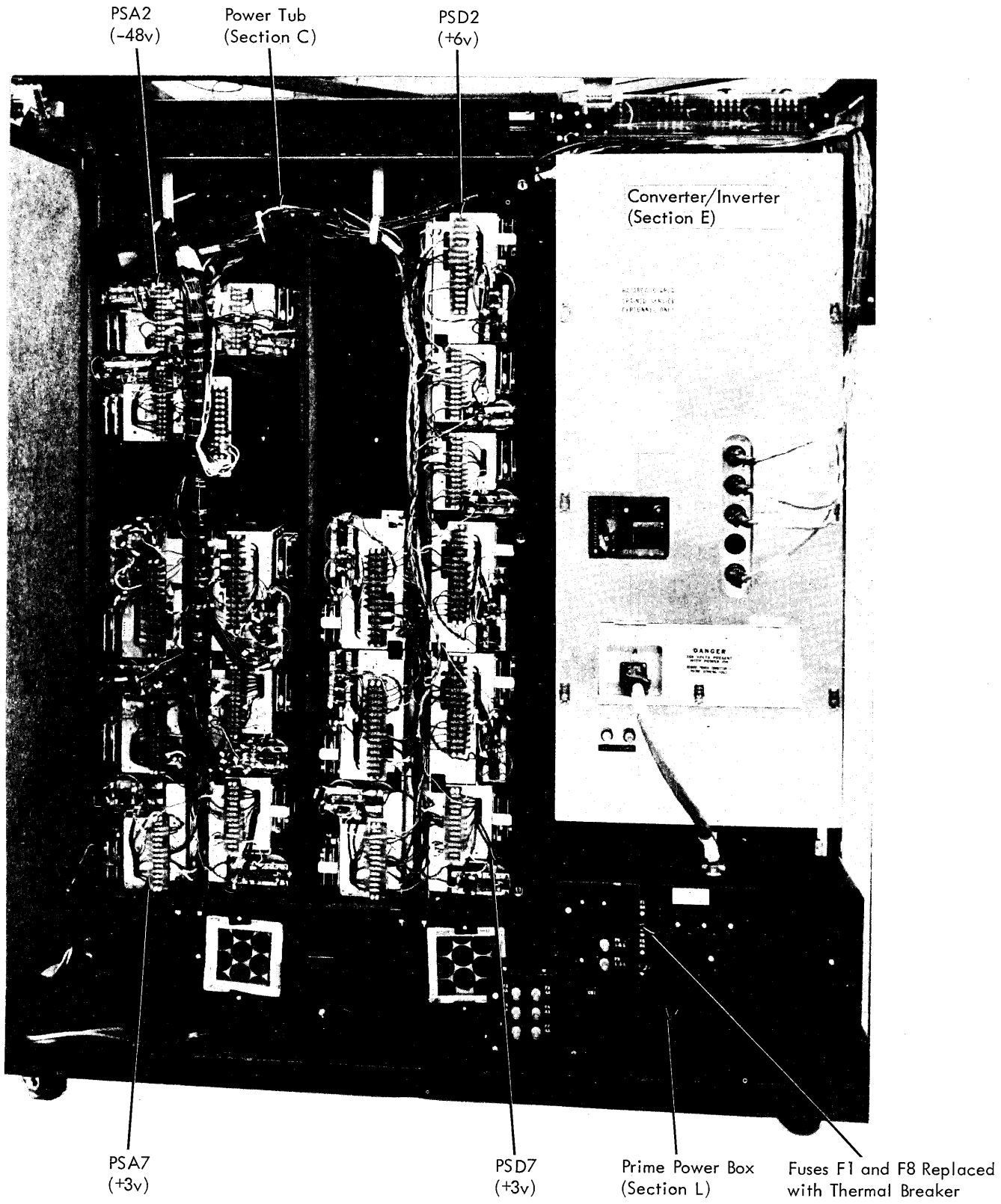


Figure 6-5. PAM Power Tub and Controls

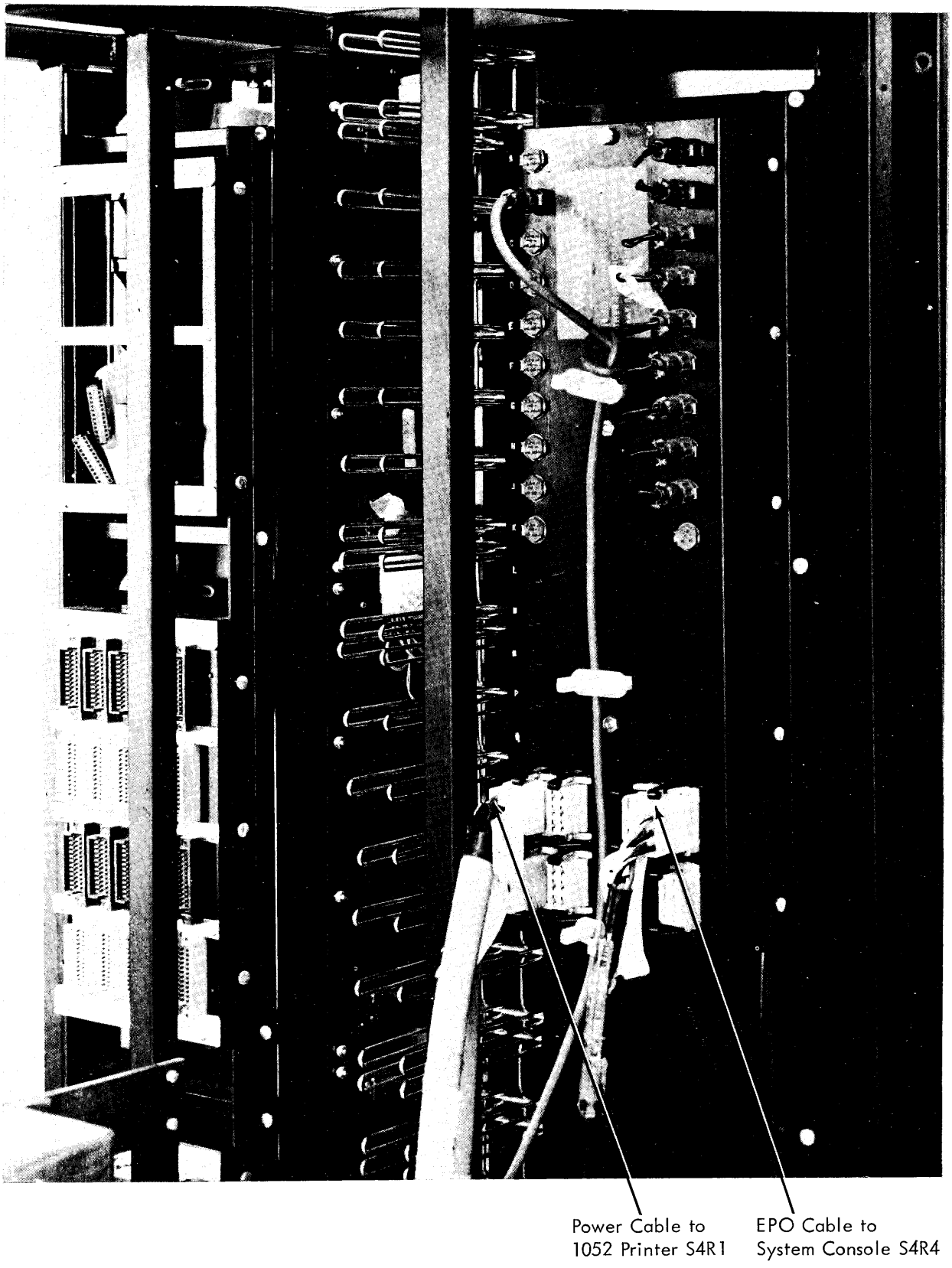


Figure 6-6. PAM Cable Entry Area

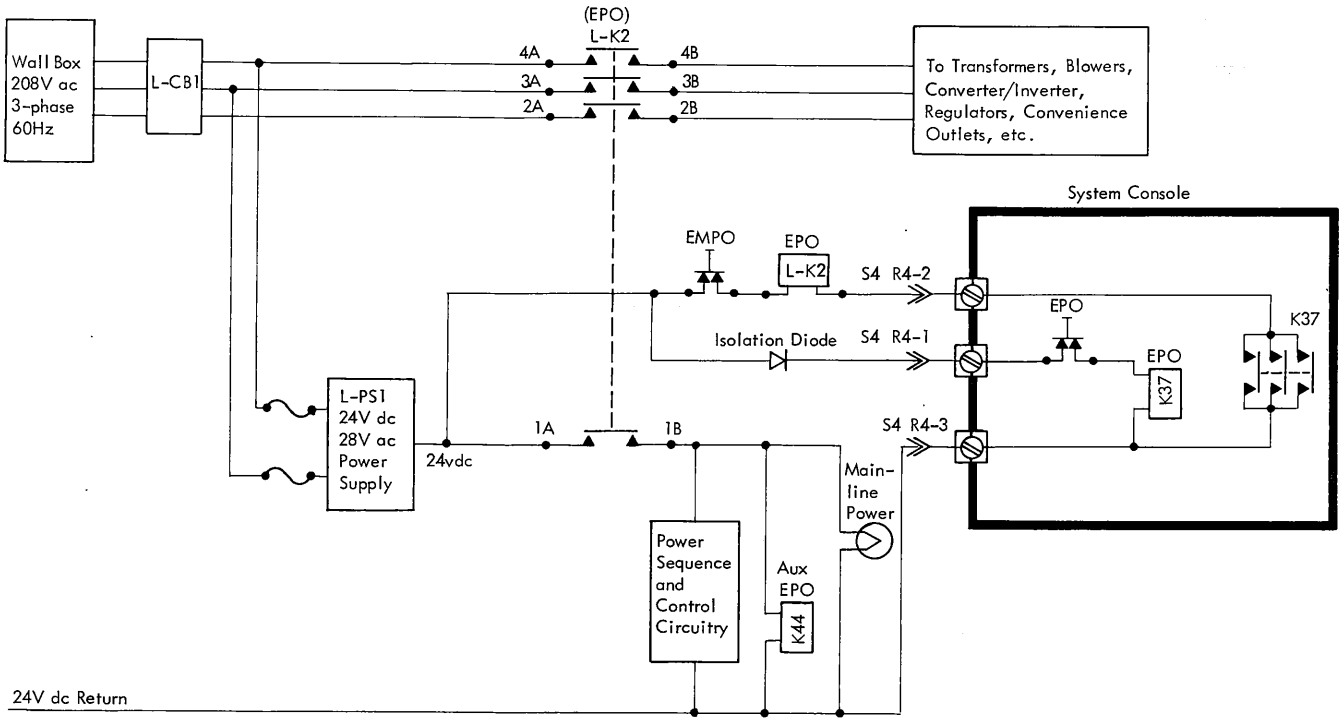
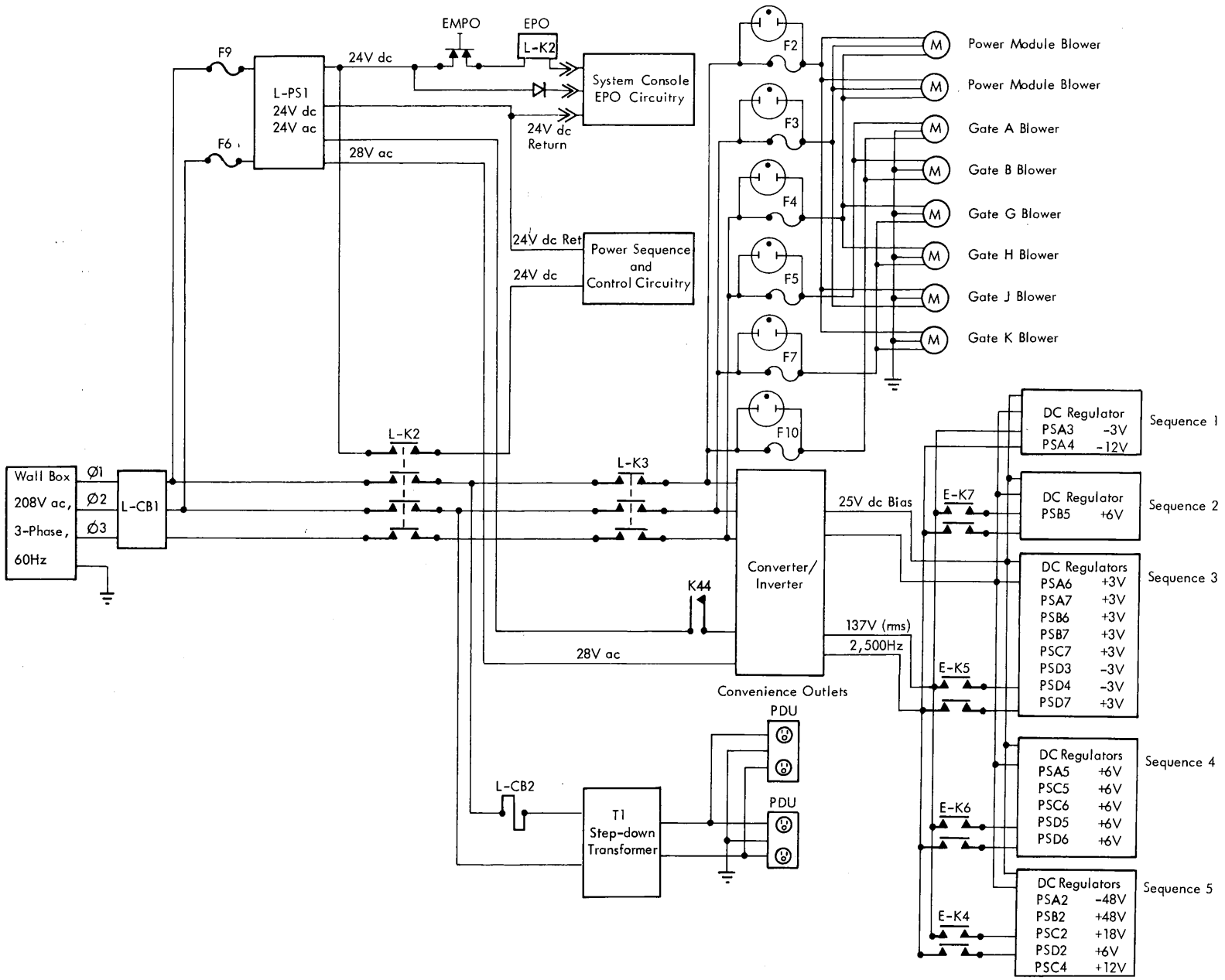
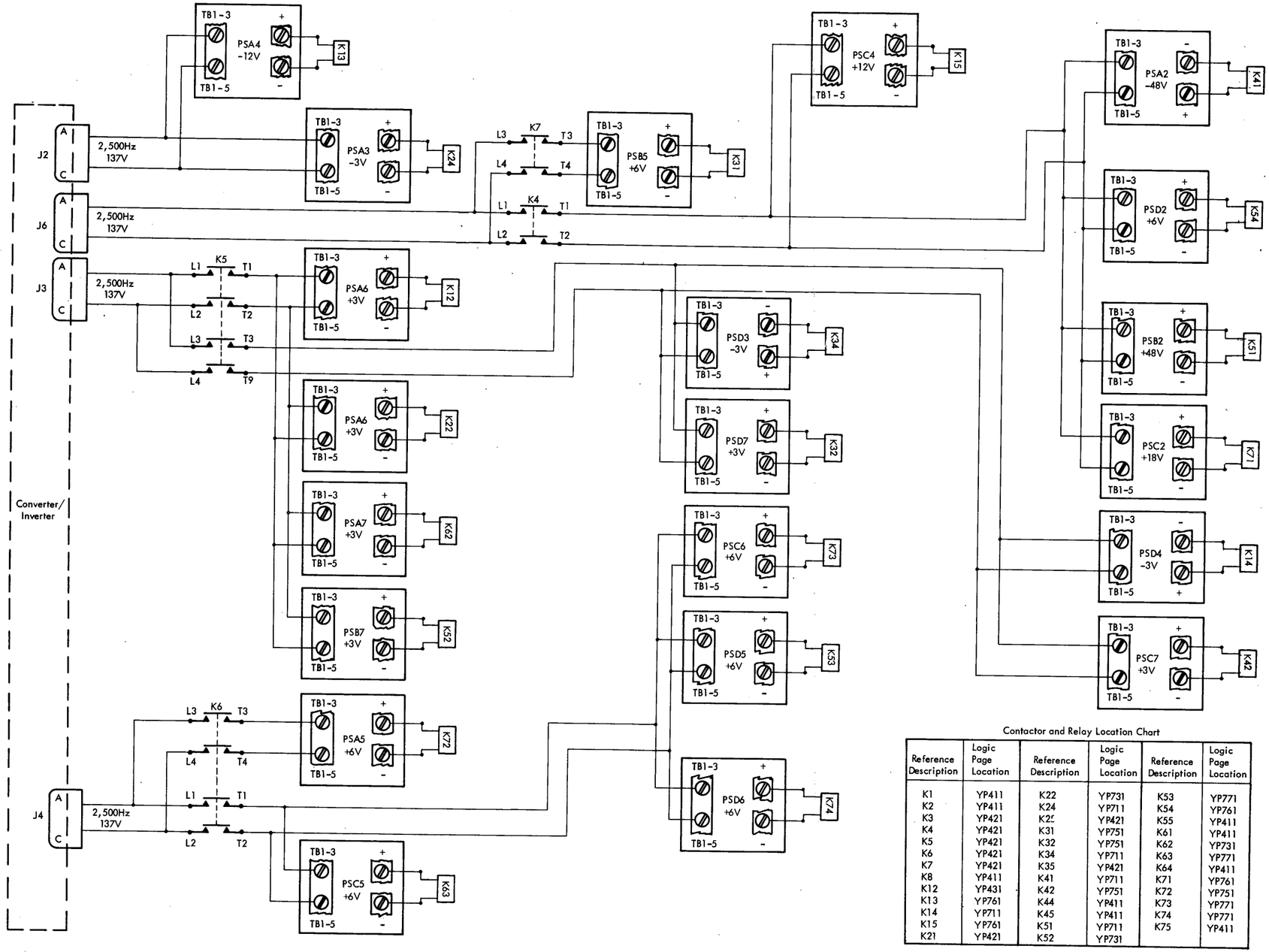


Figure 6-7. PAM Power Interlock Circuitry



●Figure 6-8. PAM AC Distribution

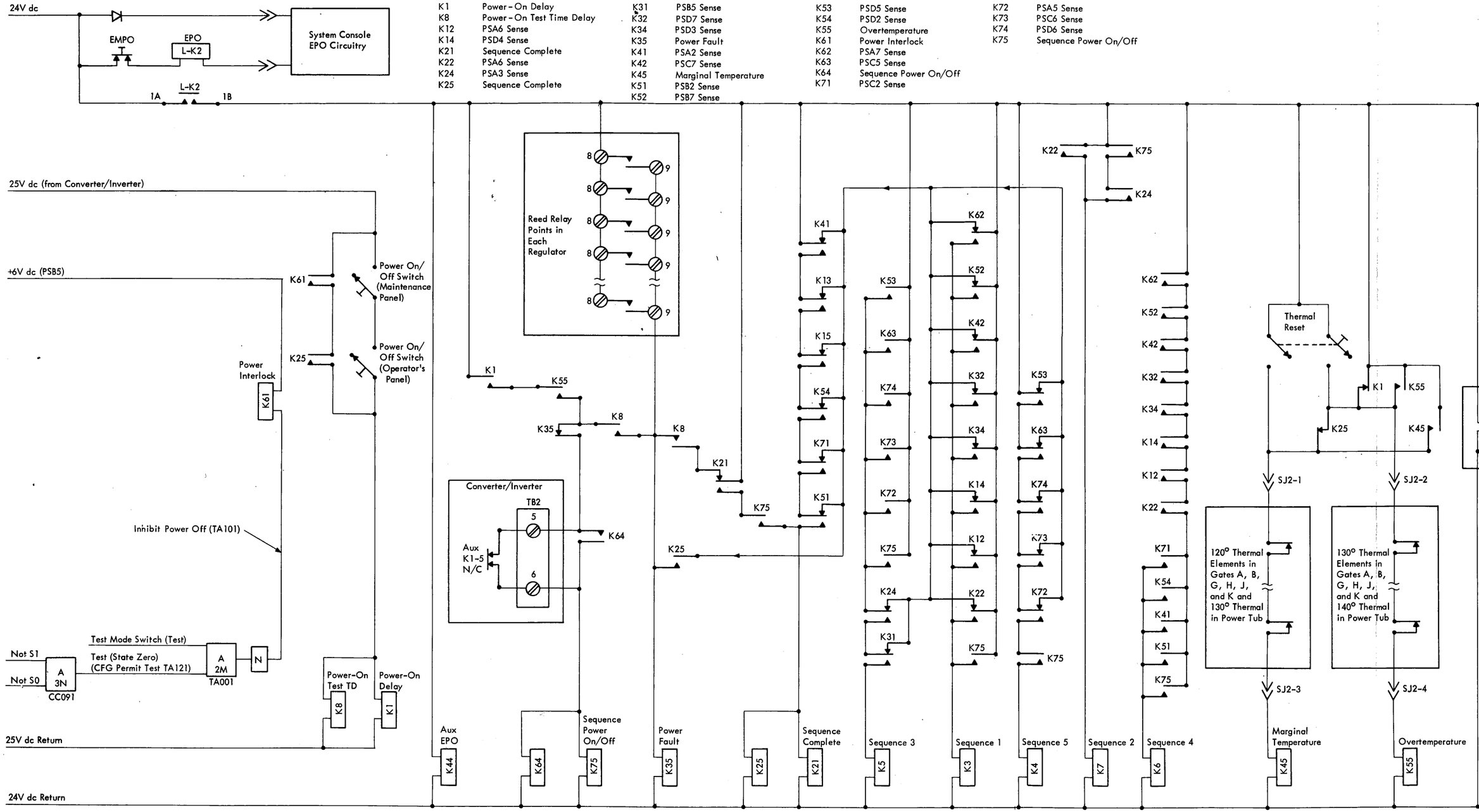


Contactor and Relay Location Chart

Reference Description	Logic Page Location	Reference Description	Logic Page Location	Reference Description	Logic Page Location
K1	YP411	K22	YP731	K53	YP771
K2	YP411	K24	YP711	K54	YP761
K3	YP421	K25	YP421	K55	YP411
K4	YP421	K31	YP751	K61	YP411
K5	YP421	K32	YP751	K62	YP731
K6	YP421	K34	YP711	K63	YP771
K7	YP421	K35	YP421	K64	YP411
K8	YP411	K41	YP711	K71	YP761
K12	YP431	K42	YP751	K72	YP751
K13	YP761	K44	YP411	K73	YP771
K14	YP711	K45	YP411	K74	YP771
K15	YP761	K51	YP711	K75	YP411
K21	YP421	K52	YP731		

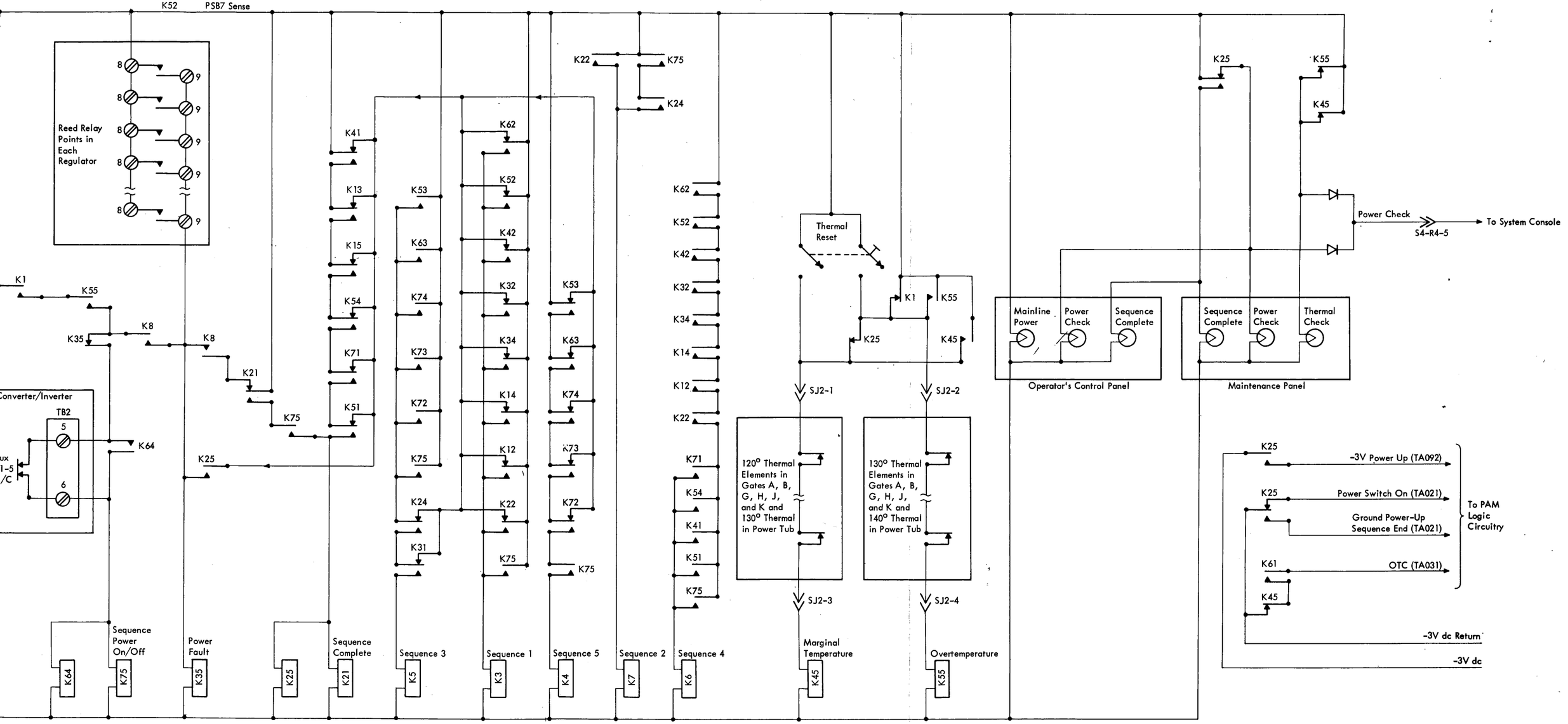
●Figure 6-9. PAM DC Regulator Supplies and Controls

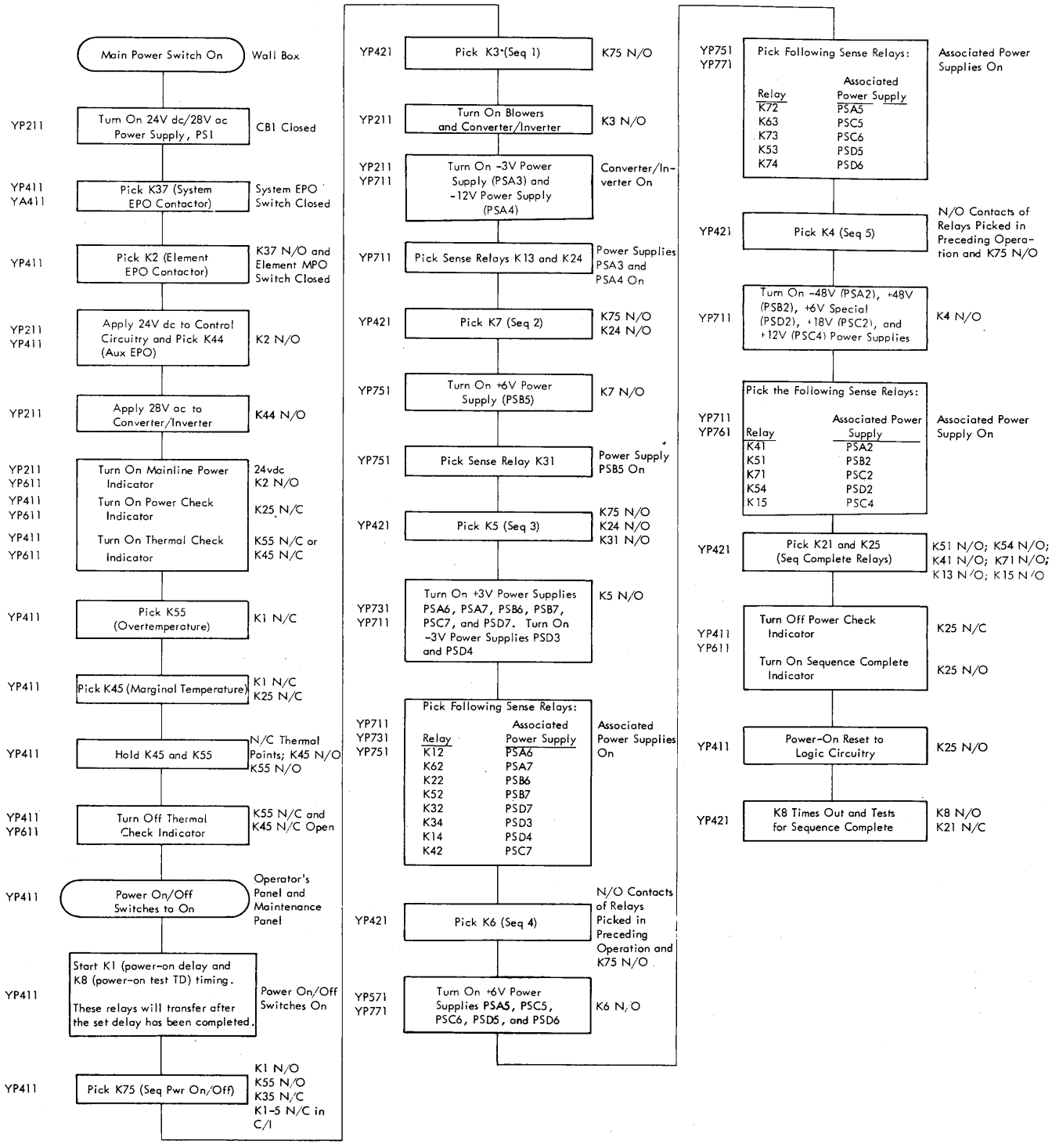
K1	Power-On Delay	K31	PSB5 Sense	K53	PSD5 Sense	K72	PSA5 Sense
K8	Power-On Test Time Delay	K32	PSD7 Sense	K54	PSD2 Sense	K73	PSC6 Sense
K12	PSA6 Sense	K34	PSD3 Sense	K55	Overtemperature	K74	PSD6 Sense
K14	PSD4 Sense	K35	Power Fault	K61	Power Interlock	K75	Sequence Power On/Off
K21	Sequence Complete	K41	PSA2 Sense	K62	PSA7 Sense		
K22	PSA6 Sense	K42	PSC7 Sense	K63	PSC5 Sense		
K24	PSA3 Sense	K45	Marginal Temperature	K64	Sequence Power On/Off		
K25	Sequence Complete	K51	PSB2 Sense	K71	PSC2 Sense		
		K52	PSB7 Sense				



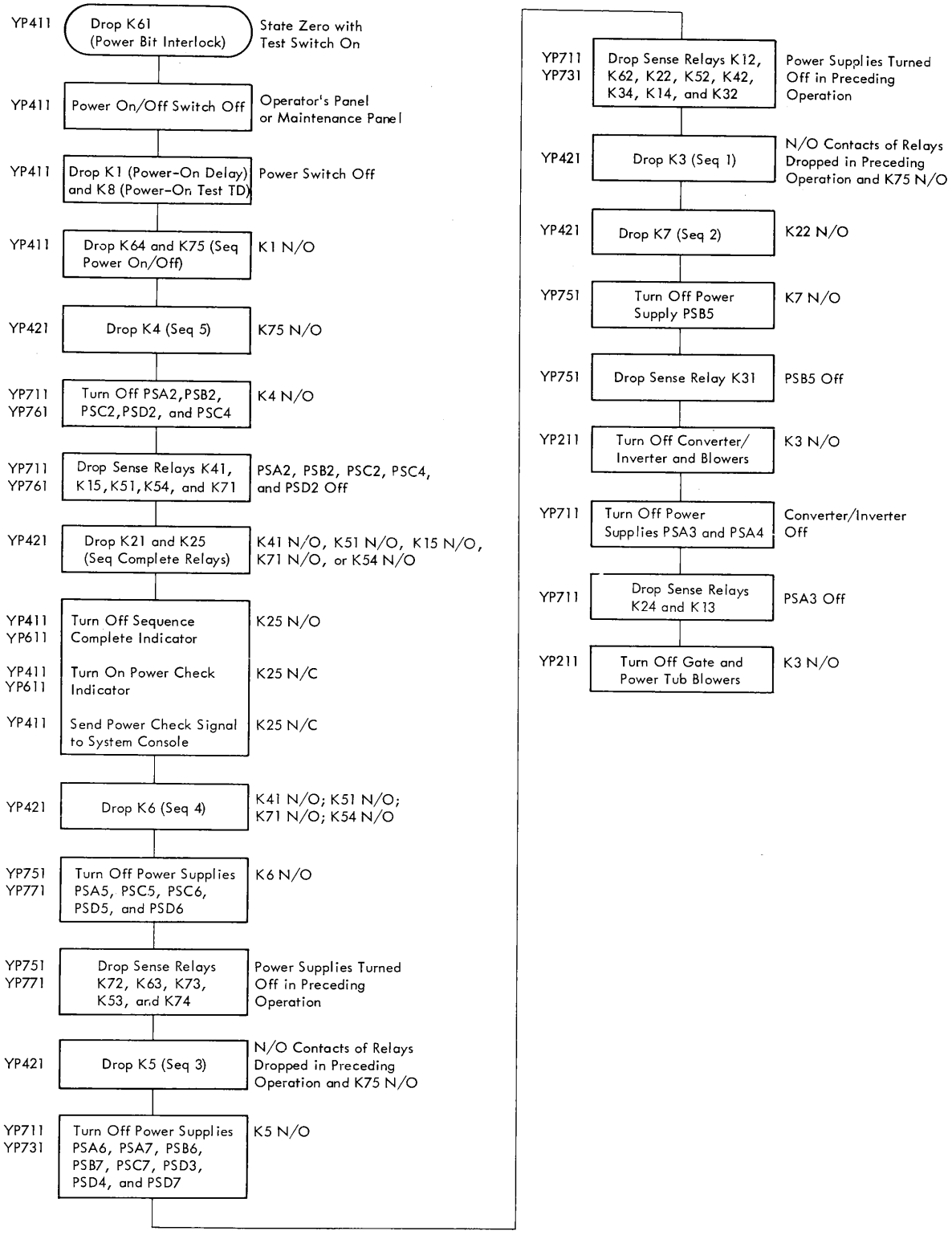
●Figure 6-10. PAM Power Sequence and Control Circuitry

Power-On Delay	K31	PSB5 Sense	K53	PSD5 Sense	K72	PSA5 Sense
Power-On Test Time Delay	K32	PSD7 Sense	K54	PSD2 Sense	K73	PSC6 Sense
PSA6 Sense	K34	PSD3 Sense	K55	Overtemperature	K74	PSD6 Sense
PSD4 Sense	K35	Power Fault	K61	Power Interlock	K75	Sequence Power On/Off
Sequence Complete	K41	PSA2 Sense	K62	PSA7 Sense		
PSA6 Sense	K42	PSC7 Sense	K63	PSC5 Sense		
PSA3 Sense	K45	Marginal Temperature	K64	Sequence Power On/Off		
Sequence Complete	K51	PSB2 Sense	K71	PSC2 Sense		
	K52	PSB7 Sense				





●Figure 6-11. PAM Power-On Flowchart


YP411
Drop K61 (Power Bit Interlock)
State Zero with Test Switch On
YP411
Power On/Off Switch Off
Operator's Panel or Maintenance Panel
YP411
Drop K1 (Power-On Delay) and K8 (Power-On Test TD)
Power Switch Off
YP411
Drop K64 and K75 (Seq Power On/Off)
K1 N/O
YP421
Drop K4 (Seq 5)
K75 N/O
YP711 YP761
Turn Off PSA2,PSB2, PSC2,PSD2, and PSC4
K4 N/O
YP711 YP761
Drop Sense Relays K41, K15,K51,K54, and K71
PSA2, PSB2, PSC2, PSC4, and PSD2 Off
YP421
Drop K21 and K25 (Seq Complete Relays)
K41 N/O, K51 N/O, K15 N/O, K71 N/O, or K54 N/O
YP411 YP611
Turn Off Sequence Complete Indicator
K25 N/O
YP411 YP611
Turn On Power Check Indicator
K25 N/C
YP411
Send Power Check Signal to System Console
K25 N/C
YP421
Drop K6 (Seq 4)
K41 N/O; K51 N/O; K71 N/O; K54 N/O
YP751 YP771
Turn Off Power Supplies PSA5, PSC5, PSC6, PSD5, and PSD6
K6 N/O
YP751 YP771
Drop Sense Relays K72, K63, K73, K53, and K74
Power Supplies Turned Off in Preceding Operation
YP421
Drop K5 (Seq 3)
N/O Contacts of Relays Dropped in Preceding Operation and K75 N/O
YP711 YP731
Turn Off Power Supplies PSA6, PSA7, PSB6, PSB7, PSC7, PSD3, PSD4, and PSD7
K5 N/O
YP711 YP731
Drop Sense Relays K12, K62, K22, K52, K42, K34, K14, and K32
Power Supplies Turned Off in Preceding Operation
YP421
Drop K3 (Seq 1)
N/O Contacts of Relays Dropped in Preceding Operation and K75 N/O
YP421
Drop K7 (Seq 2)
K22 N/O
YP751
Turn Off Power Supply PSB5
K7 N/O
YP751
Drop Sense Relay K31
PSB5 Off
YP211
Turn Off Converter/ Inverter and Blowers
K3 N/O
YP711
Turn Off Power Supplies PSA3 and PSA4
Converter/Inverter Off
YP711
Drop Sense Relays K24 and K13
PSA3 Off
YP211
Turn Off Gate and Power Tub Blowers
K3 N/O

● Figure 6-12. PAM Power-Off Flowchart

The System Console (SC) is present on the 9020D system only. All SC components and circuits associated with power distribution and control are described in this chapter. Additional information on protection and checking is in Chapter 1.

POWER SEQUENCE AND CONTROL

Power Component Locations

- Operator's control panel provides monitoring and control functions.
- Duplexed power supplies are at rear of main frame.
- Area E contains relays, terminal boards, etc., associated with power distribution and control.

Figures 7-1 through 7-5 show the various component locations within the SC.

The operator's control panel (Figure 7-1) provides monitoring and control functions for operator and maintenance personnel. These items include:

1. An EMERGENCY PULL switch for immediately removing all power from the 9020 system.
2. A POWER ON switch for starting normal power on/off sequences to the SC.
3. A POWER SUPPLY SELECT switch for selecting power supply A or B.
4. Indicators at the SC for visual determination of power on, mainline on, power sequence complete, power check, and thermal check conditions.
5. Visual indicators that show the present system power status: standby indicator, battery indicator, and individual element power check indicators.
6. A voltmeter for monitoring the +6V marginal supply presently used.
7. Marginal voltage potentiometers and indicators associated with the +6V A and B supplies.
8. A THERMAL RESET pushbutton for manually resetting a thermal check condition.

The prime power input area (Figure 7-2) is in the lower rear section of the main frame (area L). Just above this prime input area are the duplexed A and B converter/inverters and their associated dc regulator supplies (area C). The A power supplies are at the left and the B power supplies are at the right as viewed from the rear of the frame. Access to these supplies is through hinged doors.

Contactors, relays, terminal boards, etc., that are used during power sequencing and control are in area E to the rear of the operator's control panel (Figure 7-3 and 7-5).

Area S2 contains I/O receptacles to receive the 6-pin power connectors from each major element within the system. Within this cable is the emergency power-off (EPO) circuitry and power-check and on-battery signals.

A maintenance panel is in the upper right section of the B-gate but this section does not provide power control functions.

Power Interlock Circuit

- Each system CE, IOCE, SE, PAM, and TCU is power-interlocked with the SC.
- An EPO condition at the SC immediately removes power from all system elements.
- IBM 2821 Control Unit is also affected by a console EPO condition.

The 9020 power interlock system is such that power is removed from all system elements when the EPO switch is pulled at the SC. An emergency power off, therefore, cannot be performed on the SC without dropping power on the entire system. The POWER ON pushbutton should be used to remove power from the SC under normal conditions.

Figure 7-6 shows the SC power interlock circuitry. Note that under an EPO power-off condition, +24V dc is still available within the EPO cable between all elements and the SC. Two series-EPO switches are possible in the EPO circuitry: one at a remote location and the other at the SC operator's control panel. If the facility does not have a remote EPO switch, a dummy plug must be used.

With the two EPO switches closed, the SC (or any of the other elements) can pick and hold EPO contactor K37. In the SC, this circuit is from the +24V dc power supply (the outputs of PS1 and PS2 tied together through diodes), through an isolation diode, through the EPO switches, and K37.

When K37 picks, a pair of N/O points provides a pick circuit for console EPO contactor K2 and auxiliary EPO relay K17.

The three main sets of K2 N/O points gate 3-phase, 208V ac power into the main power area and to step-down transformer T1 for 115V ac convenience outlet power (Figure 7-7). Further gating of this power into the converter/inverters, dc regulators, blowers, etc., depends on the POWER-ON pushbutton as described in a later section.

The fourth set of N/o K2 points (1A-1B) applies +24V dc to the power sequence and control circuitry and turns on the MAINLINE ON indicator (Figure 7-6). Further operation of the power sequence and control circuitry also depends on the setting of the POWER-ON pushbutton as described later.

Auxiliary EPO relay K17 provides a pick for the EPO contactor within the IBM 2821 Control Unit. In addition, K17 also provides control within the power sequencing logic.

AC Distribution

- 208V, 3-phase, 60-Hz input power.

- Under normal power-off conditions, ac power is available to:
  1. 115V ac convenience outlets.
  2. PAM 1052 printer on console reading board.
  3. 24V dc/28V ac power supplies (PS1 and PS2).
  4. Contorl circuitry of both converter/inverters (28V ac).

- Under EPO conditions, the following ac/dc voltages exist:
  1. 208V ac to PS1 and PS2.
  2. 28V ac to the C/Is.
  3. 25V dc to the power sequence circuits.
  4. 24V dc to the EPO circuitry.

AC input includes 3-phase, 208V, 60-Hz power that is routed directly from the facility power outlet (Figure 7-7). Two of the three input phases are routed immediately to the 1052 Printer Keyboard associated with the PAM. This printer is logically associated with the PAM but physically located at the SC.

Turning on mainline circuit breaker CB1 applies 208V ac, single-phase power to the 24V dc/28V ac power supplies (PS1 and PS2). As described under "Power Interlock Circuit" (Figure 7-6), the 24V dc control voltage is routed through the two EPO switches and to K37 (EPO contactor). If the EPO switches are closed, K37 picks (if not already picked by another element) and provides a pick circuit for K2 (console EPO) and K17 (auxiliary EPO).

From the three main sets of K2 contacts (Figure 7-7), 208V ac, single-phase power is routed via CB2 to step-down transformer T1 which provides 115V ac to the convenience outlets. The fourth set of K2 contacts gates +24V dc into the power sequence and control circuitry. Note that the EPO points do not interrupt the 28V ac control voltage into the two converter/inverters.

Before further distribution of ac power can occur, contactors K1, K3, and K4 must be picked. The pick of these contactors is a part of the power-on sequence described later. When either K1 or K3 is picked, ac power is appied to either the B or A C/I, respectively. When K4 is picked, ac power is applied to the various gate and power tub blowers, to the PS3 7.25 ac power supply that drives the console indicators, and input power to the 1052 printer that is associated with the system console.

Under normal power-off conditions, the following ac/dc voltages exist outside the prime power compartment:

1. 208V ac to the PAM 1052 printer.
2. 115V ac at the convenience outlets.
3. 28V ac to the C/I control circuitry.
4. 25V dc to the power sequence and control circuitry.
5. 24V dc to the power sequence and control circuitry.
6. 24V dc to the EPO circuitry.

Note that these voltages (except items 1 and 2) are also available under EPO conditions. The 24V dc within the EPO cable is needed to return power to the system when the EPO condition is removed.

All power can be removed from the SC by opening main circuit breaker CB1 or the facility power outlet circuit breaker. Note that opening CB1 does not remove power from the PAM 1052 printer. To remove this power, the facility power outlet circuit breaker must be used.

DC Distribution

- Duplexed dc regulator supplies.

- Four dc regulators within each group.

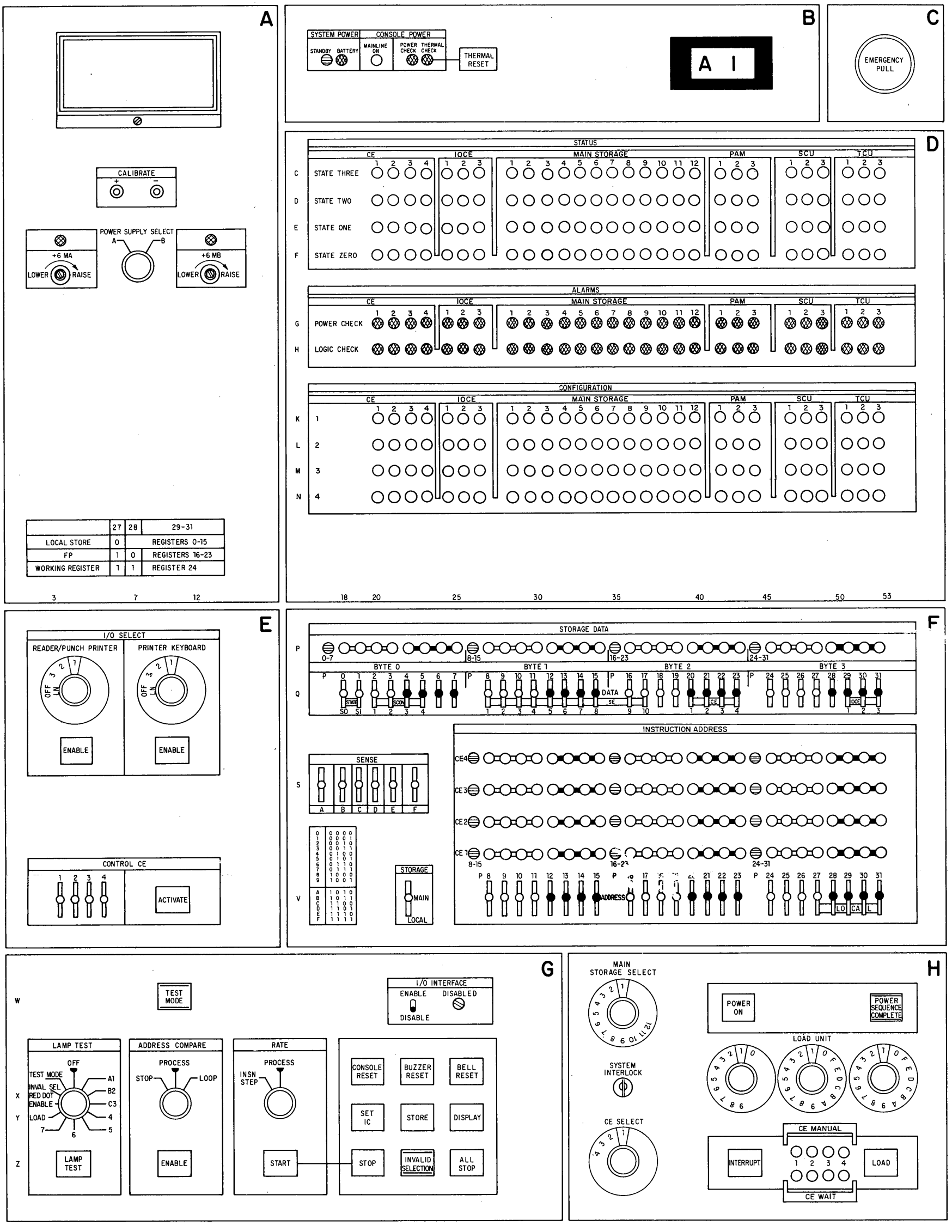
- 2500-Hz input to duplexed regulators from duplexed converter/inverters.

- Corresponding regulators (except +48V) in each group are "hard wired."

- Each of the four voltages is relay-sensed.

All dc voltages, except the +24V and +25V power sequence and control voltages, are obtained from regulators.

The SC has completely duplexed A and B dc regulator supplies that are powered by their associated duplexed A and B converter/inverters.



	27	28	29-31
LOCAL STORE	0		REGISTERS 0-15
FP	1	0	REGISTERS 16-23
WORKING REGISTER	1	1	REGISTER 24

Figure 7-1. System Console Operator's Control Panel

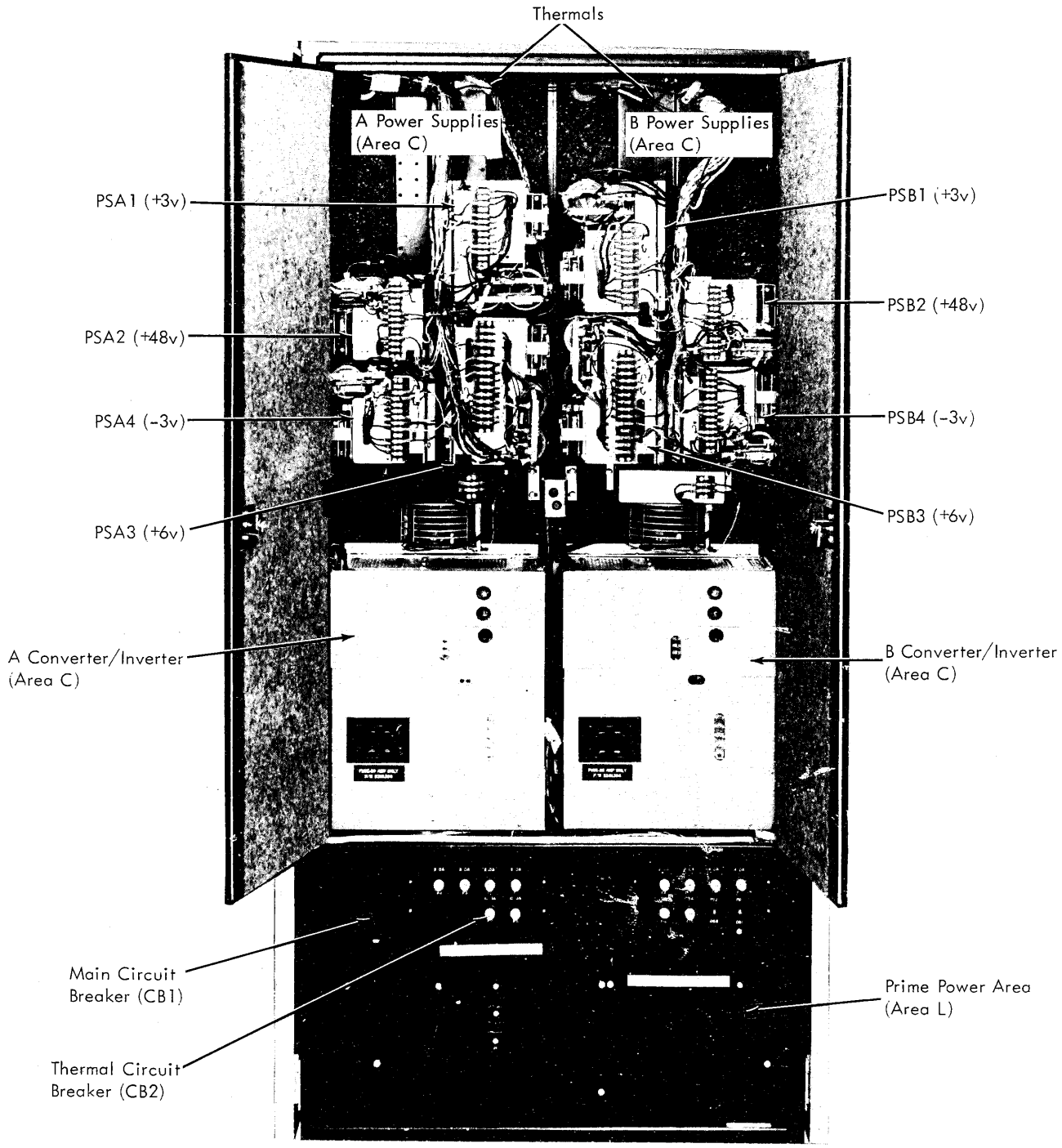


Figure 7-2. SC Power Supplies (Main Frame, Rear View)

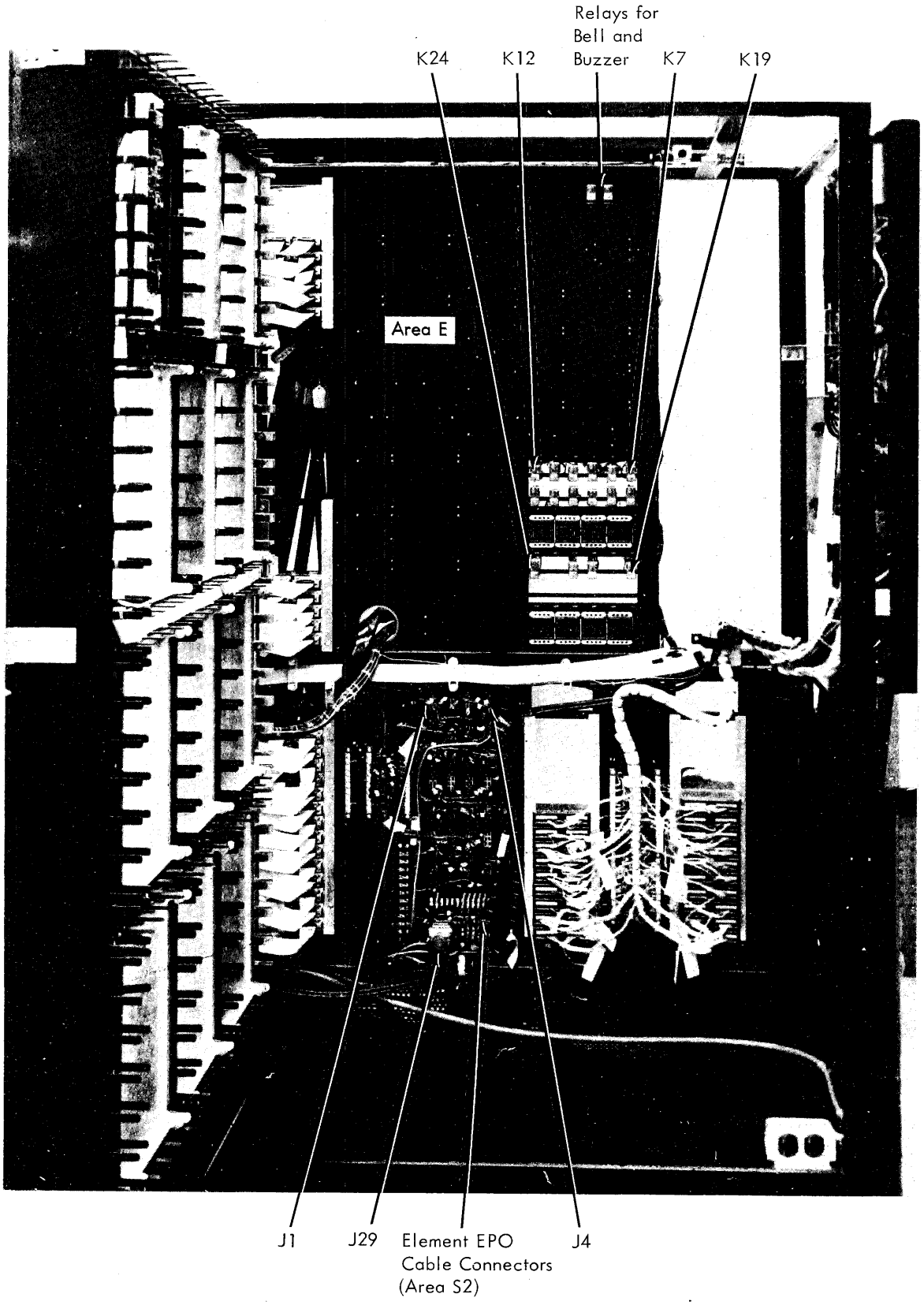


Figure 7-3. SC Power Relays and I/O Connector Areas

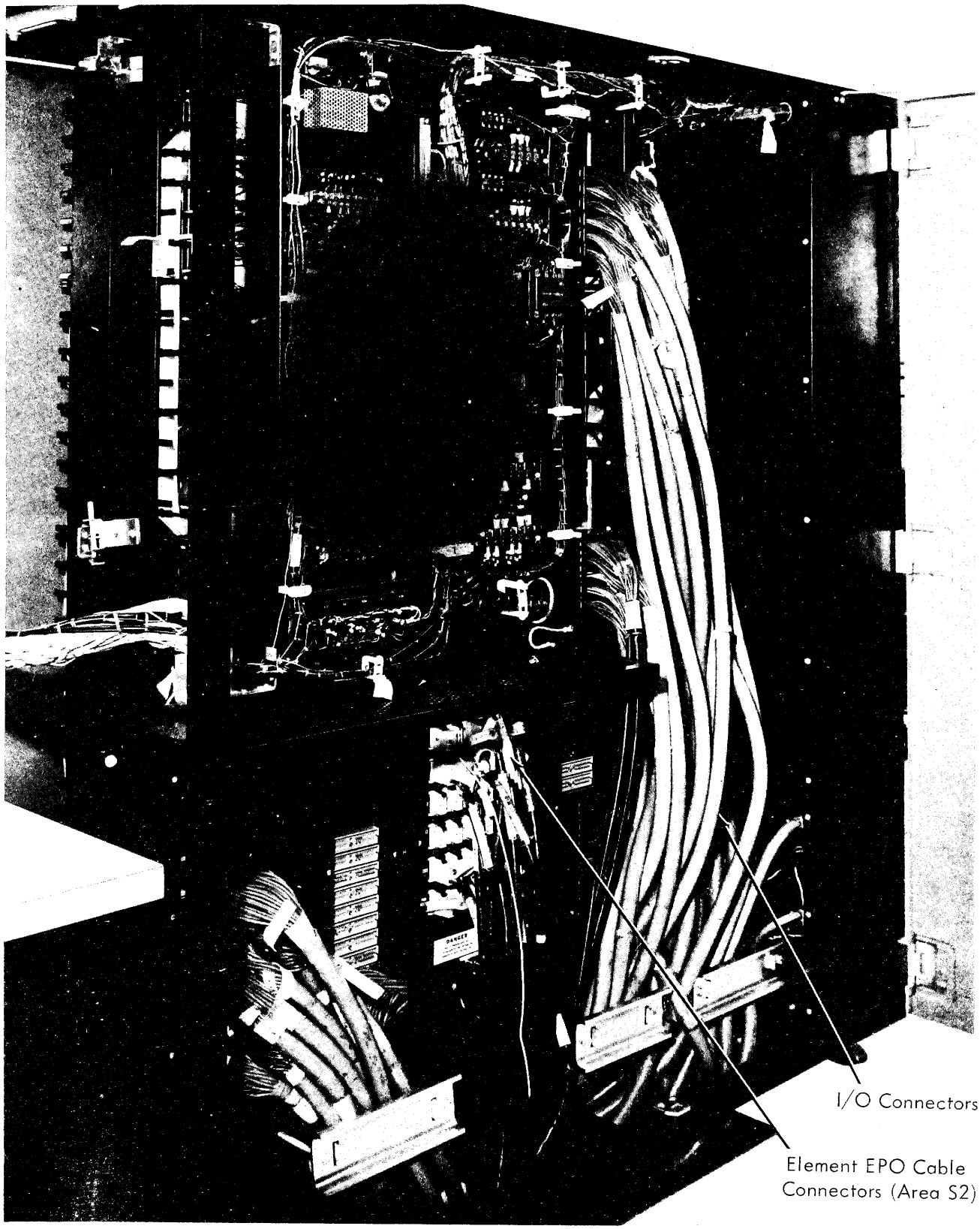


Figure 7-4. SC Power Relays and I/O Connector Area (Right Side, Overall)

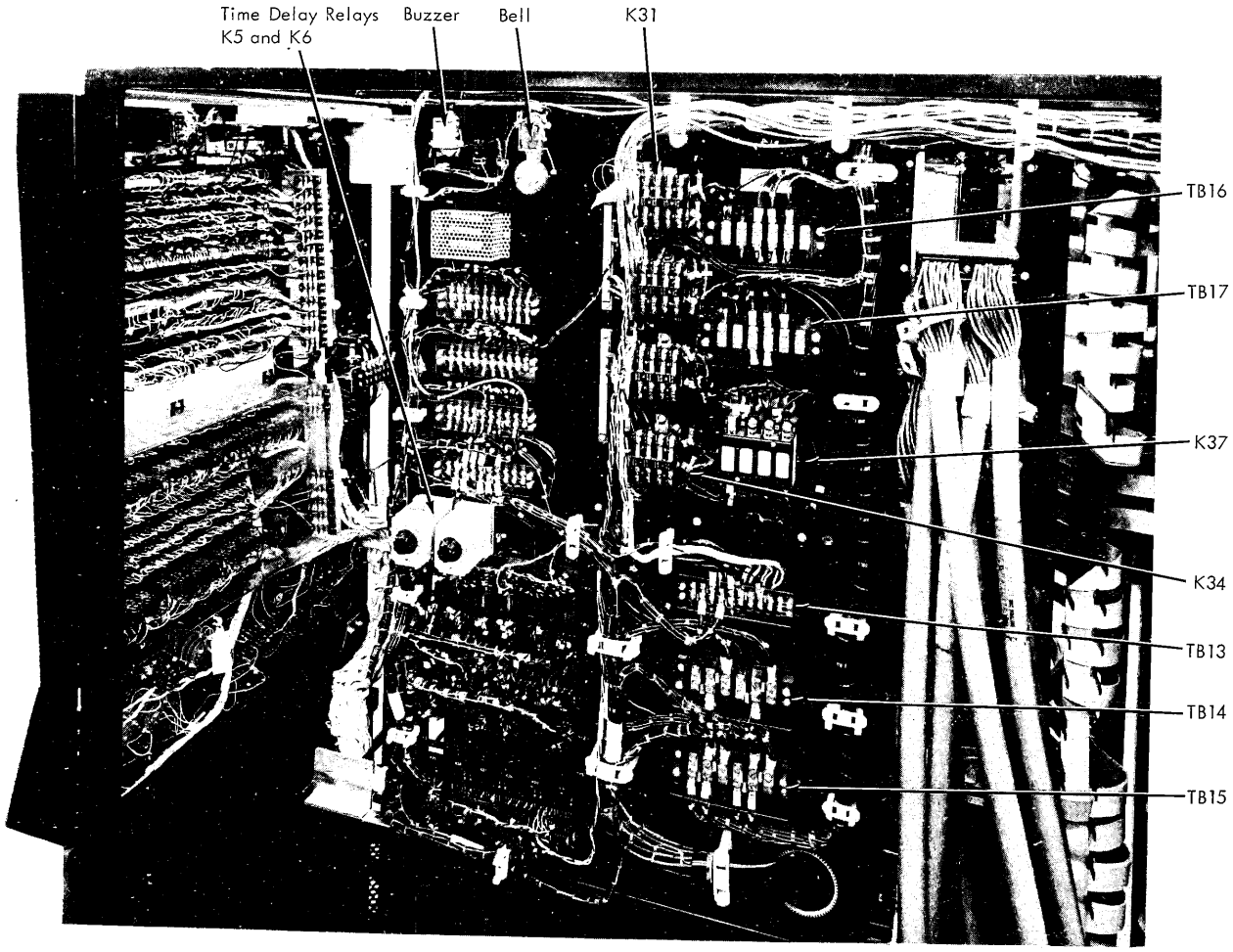


Figure 7-5. SC Power Relay and Control Section (Area E, right side)

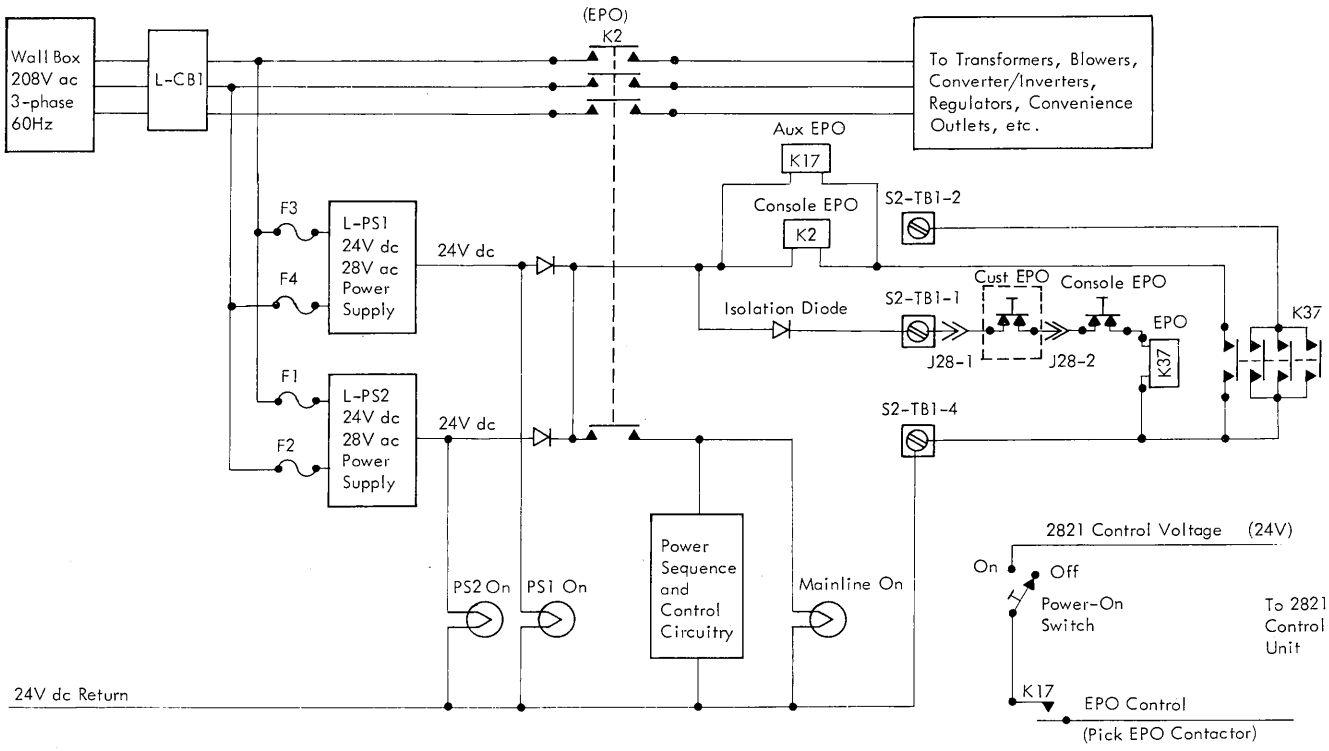


Figure 7-6. SC Power Interlock Circuitry

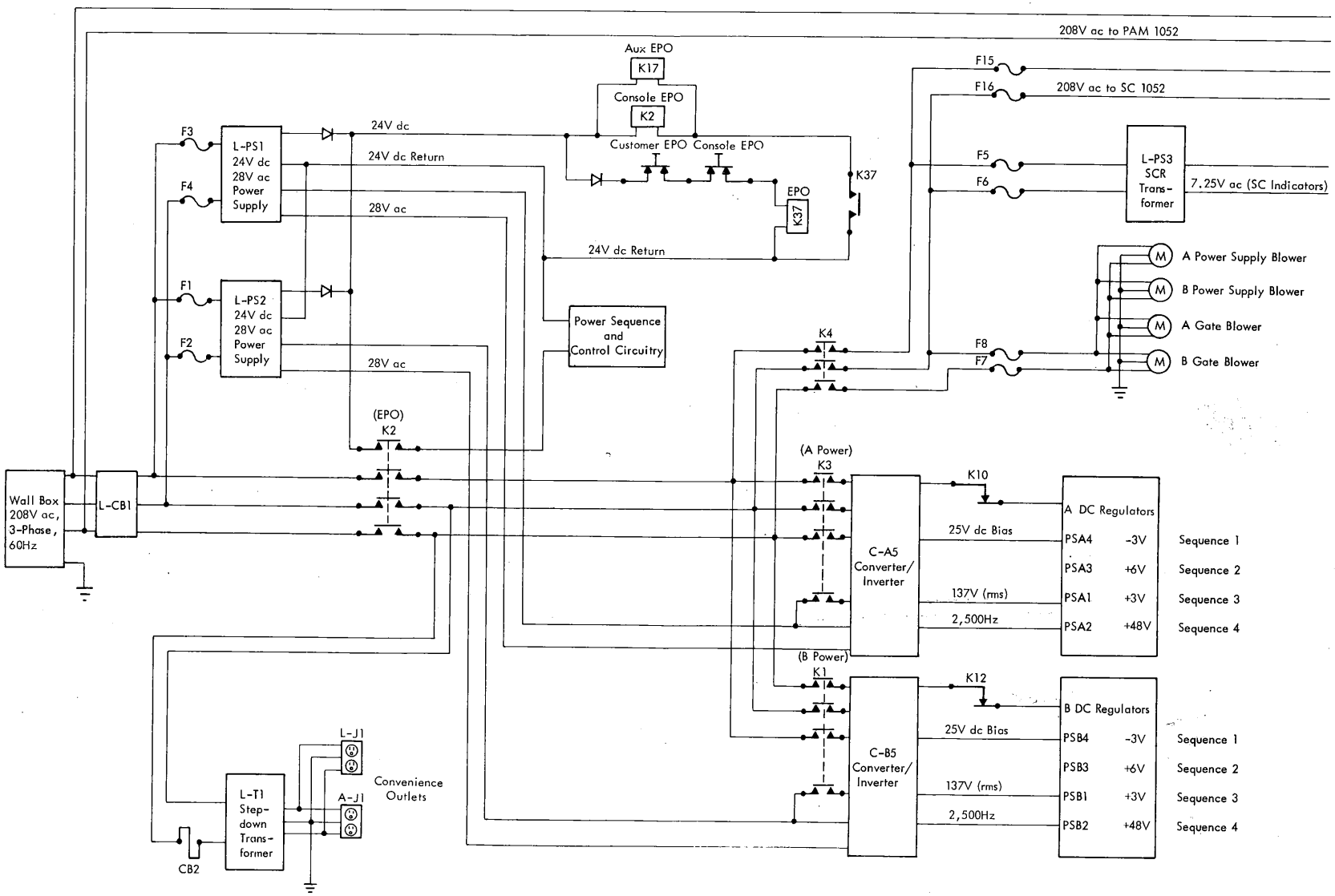


Figure 7-7. SC AC Distribution

The SC has four regulators within each power group (Figure 7-8). Only one regulator is required for each dc voltage to provide the required amount of power. Inputs to these regulators are supplied by the corresponding converter/inverters as a 2500-Hz, 137V (rms) square-wave. Regulator inputs are applied so that the regulator voltages sequence up in four steps: -3V, +6V, +3V, and +48V. For a detailed description of this operation, refer to "Power-On Sequence".

The paired regulator outputs from the -3V, +6V, and +3V supplies are "hard wired." At any given time, only one C/I is on and supplying input power to its associated group of regulators. The +48V regulator outputs are not wired like the logic voltages; they are gated by relays K9 and K11, depending on which power group is used.

Each of the four voltage levels is monitored by a sense relay which controls the proper power on and off sequencing in the SC SLT logic. Table 7-1 lists the various regulators with their voltage and current ratings, sense relays, and terminal board connections.

Table 7-1. SC Regulator Ratings, Distribution, and Sensing

Regulator	Nominal Voltage	Ampere Rating	Logic Gate	Terminal Board	Sense Relay
PSA1	+3	40	A	A-TB1-12, A-TB2-12	K21
PSB1	+3	40	B	B-TB1-8, B-TB2-8	
PSA2	+48	2	A	A-TB1-6, A-TB2-6	K24
PSB2	+48	2	B	B-TB1-6, B-TB2-6	
PSA3	+6	40	A	A-TB1-8, A-TB2-8	K22
PSB3	+6	40	B	B-TB1-12, B-TB2-12	
PSA4	-3	20	A	A-TB1-10, A-TB2-10	K19
PSB4	-3	20	B	B-TB1-10, B-TB2-10	

Power-On Sequence

- Duplex power and simplex controls.
- Power supply A or B is selected by a control panel POWER SUPPLY SELECT switch.
- 2821 Control Unit power supplies are the first to sequence on.
- SC voltages sequence on second in four groups:
  1. -3V supply
  2. +6V supply
  3. +3V supply
  4. +48V supply

The SC contains duplexed power in terms of converter/inverters and dc regulator supplies; however, simplex circuitry performs the power sequence and control functions. The system logic pages and Figure 7-9 indicate the selection of power supply B. Therefore, the following description considers the selection of the B power group. Figure 7-10 is applicable for the selection of either power supply A or B.

Before the power-on sequence can be started, main circuit breaker CB1 must be closed, system console master EPO contactor K37 must be picked, and SC EPO contactor and relay K2 and K17 must be picked.

Before the power-on sequence begins, the following conditions exist:

1. The MAINLINE ON indicator is on.
2. The POWER CHECK indicator is on through the K13 N/C points.
3. Relays K15 (low thermal) and K16 (high thermal) are picked if all thermal elements are in their N/C position. These pick circuits are through the K6 N/C points for K15, and through the K6 N/C and K13 N/C points for K16. Both relays establish hold circuits through their N/O points and remain picked until the temperature within the SC rises to the level that will open one or both of the circuits. The pick of these two relays is fast enough so that the THERMAL CHECK indicator on the operator's control panel appears to remain off.
4. Relay K10 (reset A) is picked to hold the A dc voltage regulators in a reset state. This reset is accomplished by opening the 25V dc bias circuit from the A C/I to its regulators. Note that even though the A C/I is not used (because the B supply is selected), 28V ac from PS1 is still available as input.

The power-on sequence is now started by pressing POWER ON, which is a backlighted latch-type switch on the control panel. Pressing this pushbutton picks three relays in parallel: K18 (power-on auxiliary), K6 (power-on delay), and K5 (power-on check). The K18 N/O points immediately turn on the POWER ON pushbutton backlight. Because the power-on sequence takes a few seconds to be completed, this indication serves as a reminder to the operator that the sequence has been started.

Relays K6 and K5 are time delay relays adjustable between 5 and 30 seconds. By adjusting the delay of relay K6 in the SC and comparable time delay relays in each of the other system elements to different values, a staggered system power-on sequence can be established.

The SC delay must, however, be a minimum of 10 seconds to allow the reset of one console power group to take effect before main power is applied. A setting of less than 10 seconds could result in destruction of axe assemblies on the power supplies.

Relay K5 (power-on check) is adjustable to time out after the SC power-on sequence is completed. A realistic

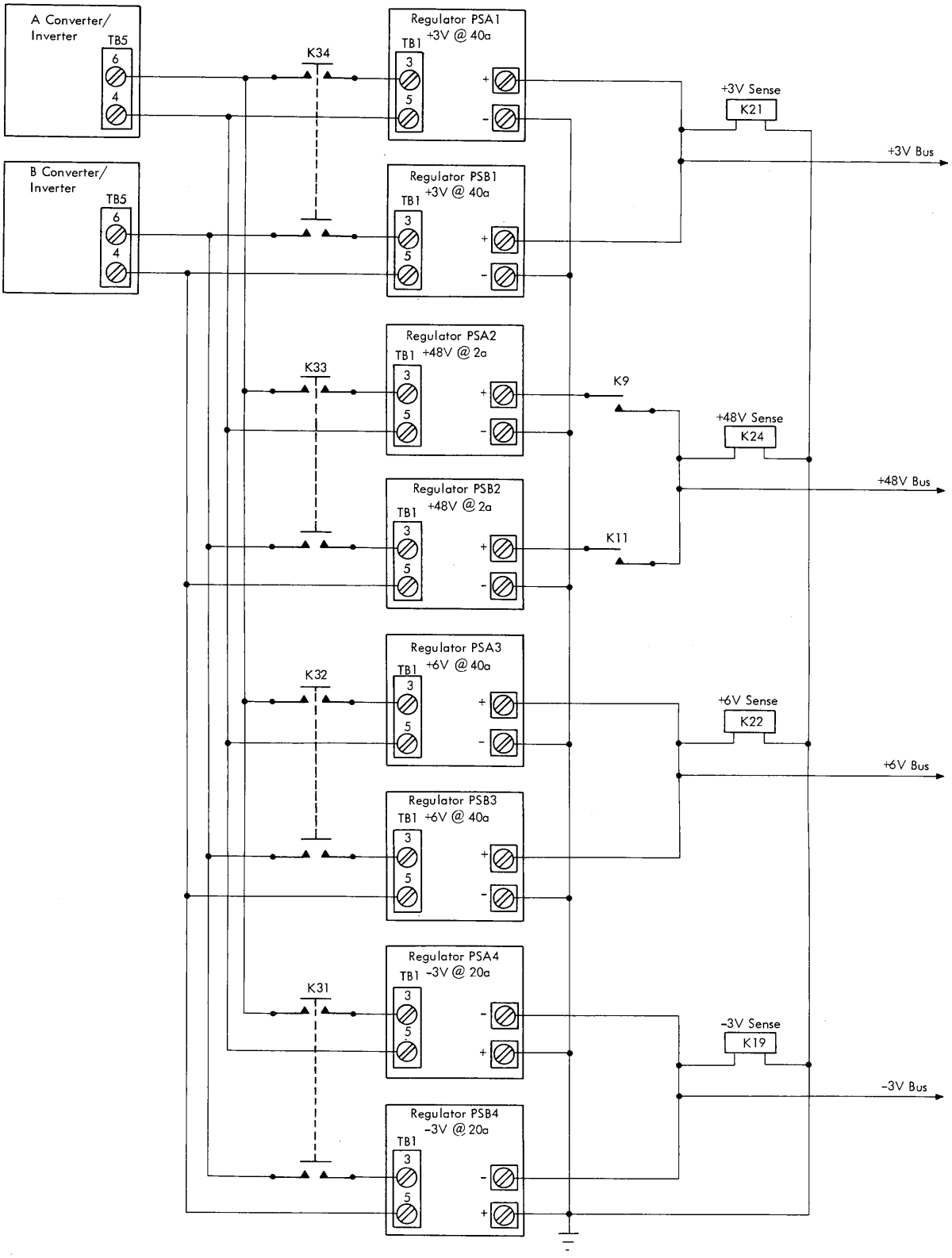
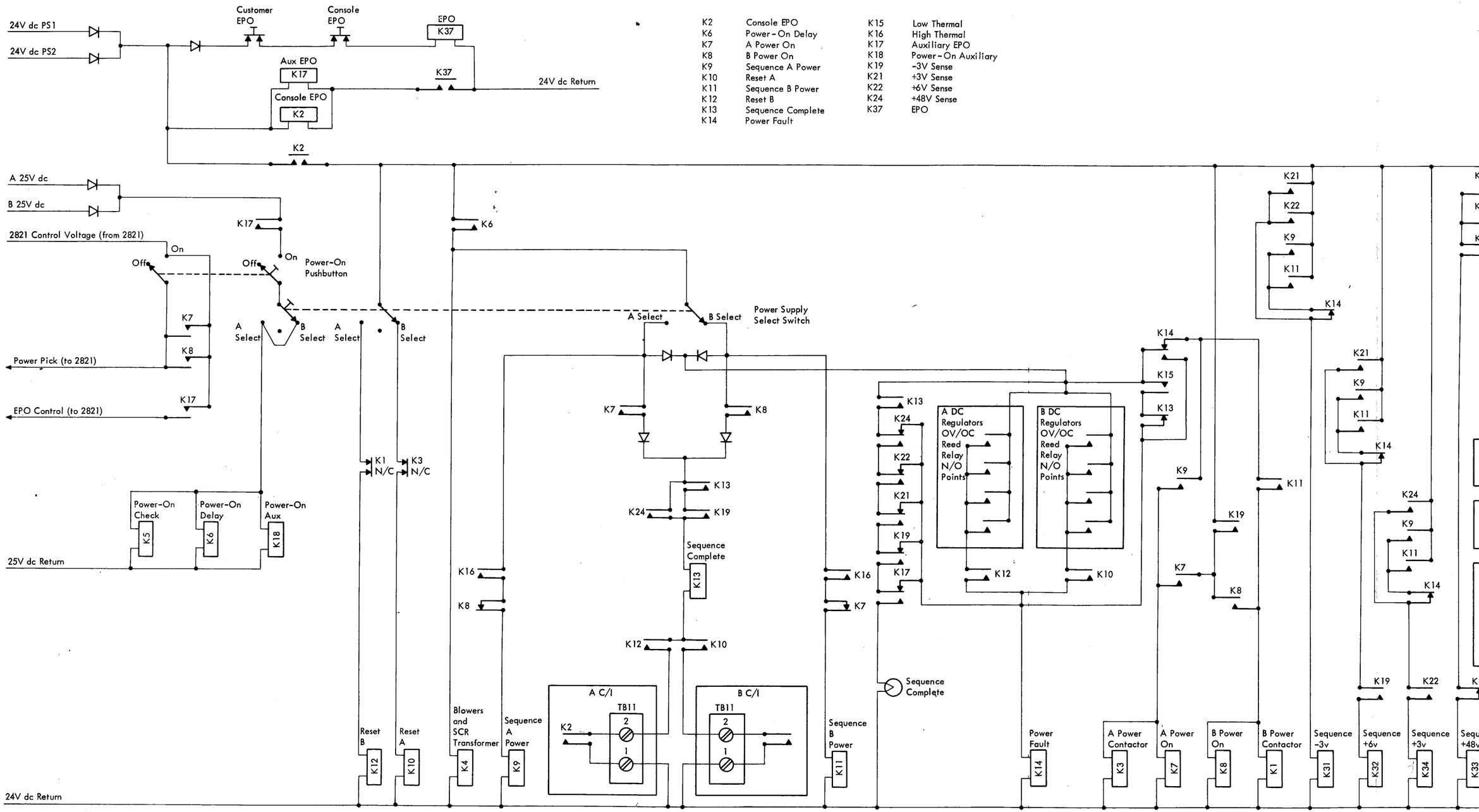


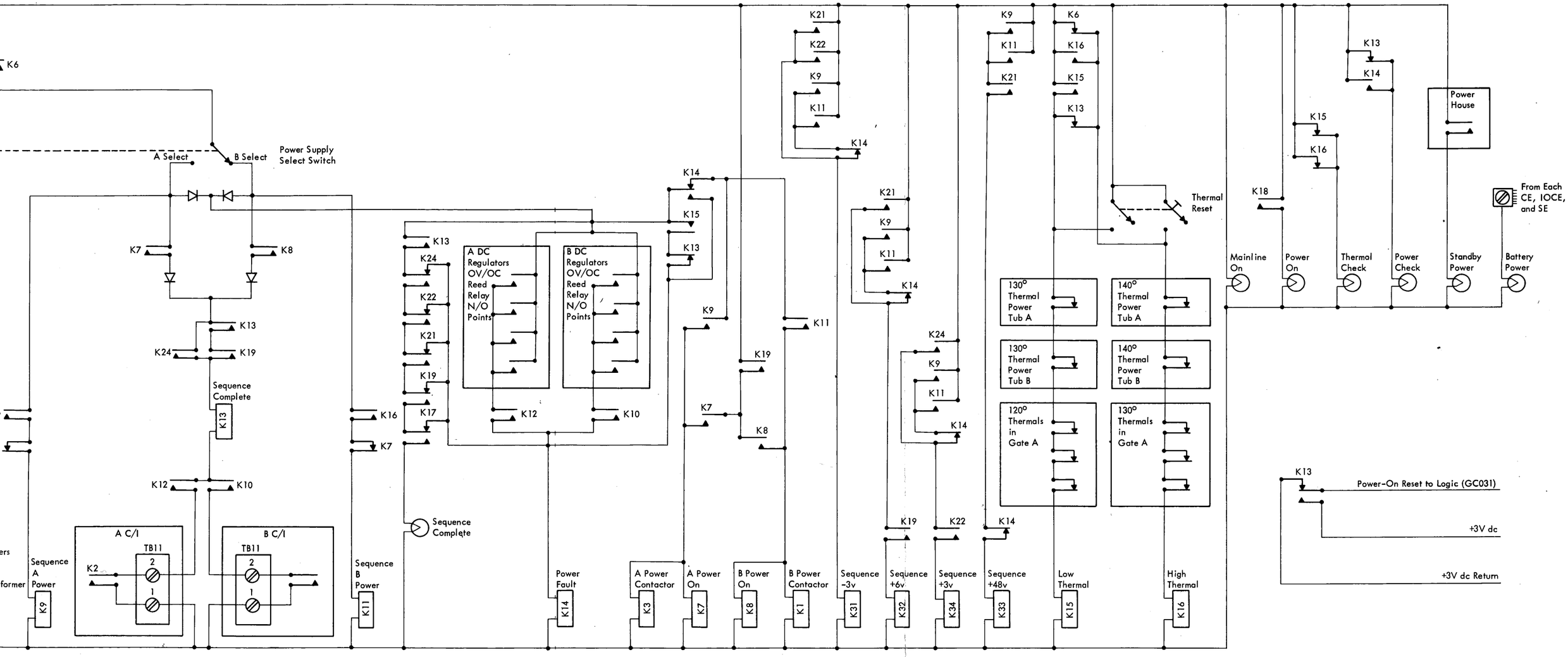
Figure 7-8. SC DC Voltage Regulator Supplies and Controls

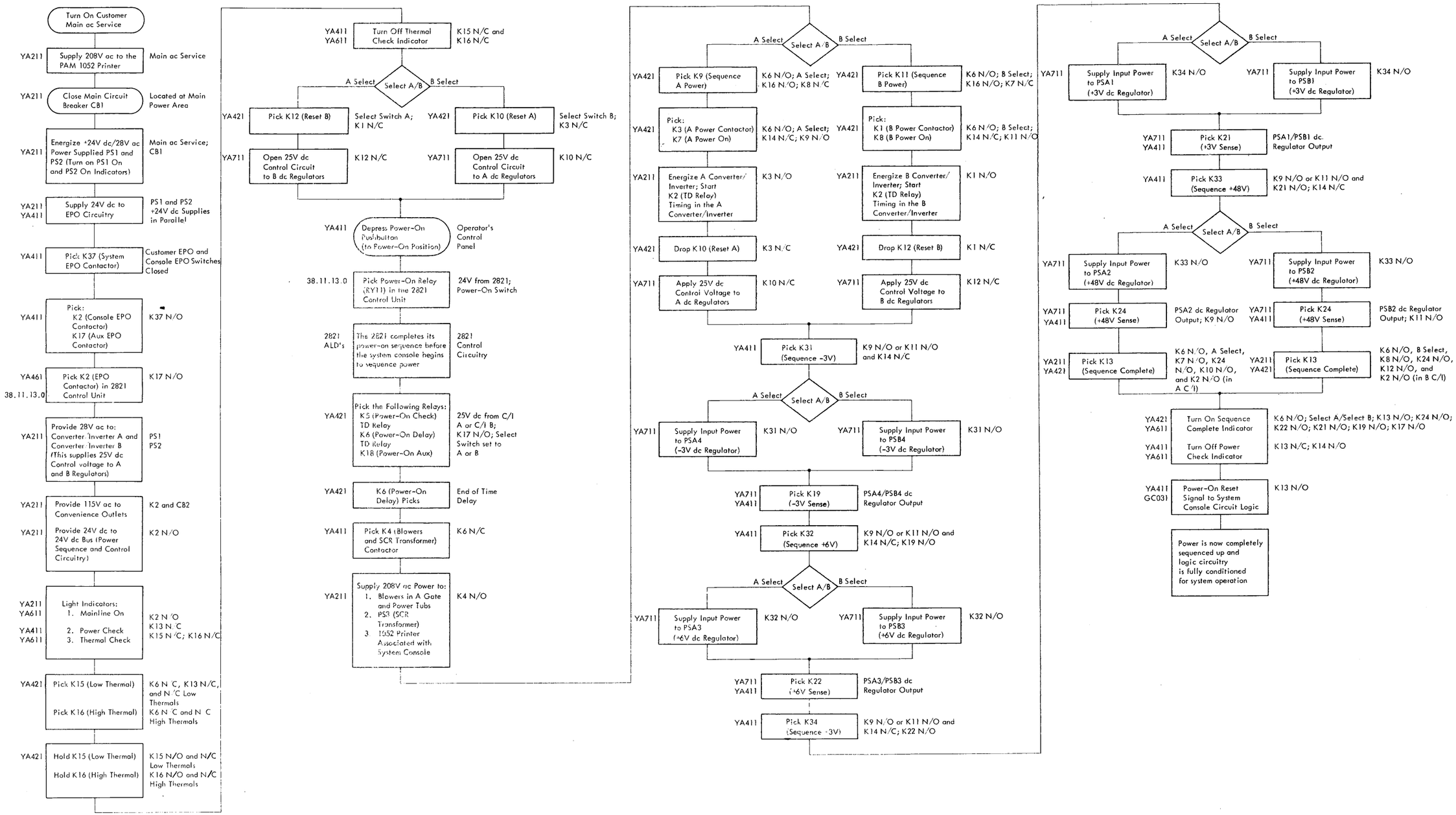


K2	Console EPO	K15	Low Thermal
K6	Power-On Delay	K16	High Thermal
K7	A Power On	K17	Auxiliary EPO
K8	B Power On	K18	Power-On Auxiliary
K9	Sequence A Power	K19	-3V Sense
K10	Reset A	K21	+3V Sense
K11	Sequence B Power	K22	+6V Sense
K12	Reset B	K24	+48V Sense
K13	Sequence Complete	K37	EPO
K14	Power Fault		

●Figure 7-9. SC Power Sequence and Control Circuitry

K2	Console EPO	K15	Low Thermal
K6	Power-On Delay	K16	High Thermal
K7	A Power On	K17	Auxiliary EPO
K8	B Power On	K18	Power-On Auxiliary
K9	Sequence A Power	K19	-3V Sense
K10	Reset A	K21	+3V Sense
K11	Sequence B Power	K22	+6V Sense
K12	Reset B	K24	+48V Sense
K13	Sequence Complete	K37	EPO
K14	Power Fault		




Turn On Customer Main ac Service
YA211 Supply 208V ac to the PAM 1052 Printer — Main ac Service
YA211 Close Main Circuit Breaker CB1 — Located at Main Power Area
YA211 Energize +24V dc/28V ac Power Supplied PS1 and PS2 (Turn on PS1 On and PS2 On Indicators) — Main ac Service; CB1
YA211 YA411 Supply 24V dc to EPO Circuitry — PS1 and PS2 +24V dc Supplies in Parallel
YA411 Pick K37 (System EPO Contactor) — Customer EPO and Console EPO Switches Closed
YA411 Pick: K2 (Console EPO Contactor) K17 (Aux EPO Contactor) — K37 N/O
YA461 38.11.13.0 Pick K2 (EPO Contactor) in 2821 Control Unit — K17 N/O
YA211 Provide 28V ac to: Converter Inverter A and Converter Inverter B (This supplies 25V dc Control voltage to A and B Regulators) — PS1 PS2
YA211 Provide 115V ac to Convenience Outlets — K2 and CB2
YA211 Provide 24V dc to 24V dc Bus (Power Sequence and Control Circuitry) — K2 N/O
YA211 YA611 YA411 YA611 Light Indicators: 1. Mainline On 2. Power Check 3. Thermal Check — K2 N/O K13 N/C K15 N/C; K16 N/C
YA421 Pick K15 (Low Thermal) Pick K16 (High Thermal) — K6 N/C, K13 N/C, and N/C Low Thermals K6 N/C and N/C High Thermals
YA421 Hold K15 (Low Thermal) Hold K16 (High Thermal) — K15 N/O and N/C Low Thermals K16 N/O and N/C High Thermals
YA411 YA611 Turn Off Thermal Check Indicator — K15 N/C and K16 N/C
A Select Select A/B B Select
YA421 Pick K12 (Reset B) — Select Switch A; K1 N/C
YA421 Pick K10 (Reset A) — Select Switch B; K3 N/C
YA711 Open 25V dc Control Circuit to B dc Regulators — K12 N/C
YA711 Open 25V dc Control Circuit to A dc Regulators — K10 N/C
YA411 Depress Power-On Pushbutton (to Power-On Position) — Operator's Control Panel
38.11.13.0 Pick Power-On Relay (RY11) in the 2821 Control Unit — 24V from 2821; Power-On Switch
2821 ALD's The 2821 completes its power-on sequence before the system console begins to sequence power — 2821 Control Circuitry
YA421 Pick the Following Relays: K5 (Power-On Check) TD Relay K6 (Power-On Delay) TD Relay K18 (Power-On Aux) — 25V dc from C/I A or C/I B; K17 N/O; Select Switch set to A or B
YA421 K6 (Power-On Delay) Picks — End of Time Delay
YA411 Pick K4 (Blowers and SCR Transformer) Contactor — K6 N/C
YA211 Supply 208V ac Power to: 1. Blowers in A Gate and Power Tubs 2. PS3 (SCR Transformer) 3 1052 Printer Associated with System Console — K4 N/O
A Select Select A/B B Select
YA421 Pick K9 (Sequence A Power) — K6 N/O; A Select; K16 N/C; K8 N/C
YA421 Pick K11 (Sequence B Power) — K6 N/O; B Select; K16 N/O; K7 N/C
YA421 Pick: K3 (A Power Contactor) K7 (A Power On) — K6 N/O; A Select; K14 N/C; K9 N/O
YA421 Pick: K1 (B Power Contactor) K8 (B Power On) — K6 N/O; B Select; K14 N/C; K11 N/O
YA211 Energize A Converter/Inverter; Start K2 (TD Relay) Timing in the A Converter/Inverter — K3 N/O
YA211 Energize B Converter/Inverter; Start K2 (TD Relay) Timing in the B Converter/Inverter — K1 N/O
YA421 Drop K10 (Reset A) — K3 N/C
YA421 Drop K12 (Reset B) — K1 N/C
YA711 Apply 25V dc Control Voltage to A dc Regulators — K10 N/C
YA711 Apply 25V dc Control Voltage to B dc Regulators — K12 N/C
YA411 Pick K31 (Sequence -3V) — K9 N/O or K11 N/O and K14 N/C
A Select Select A/B B Select
YA711 Supply Input Power to PSA4 (-3V dc Regulator) — K31 N/O
YA711 Supply Input Power to PSB4 (-3V dc Regulator) — K31 N/O
YA711 YA411 Pick K19 (-3V Sense) — PSA4/PSB4 dc Regulator Output
YA411 Pick K32 (Sequence +6V) — K9 N/O or K11 N/O and K14 N/C; K19 N/O
A Select Select A/B B Select
YA711 Supply Input Power to PSA3 (+6V dc Regulator) — K32 N/O
YA711 Supply Input Power to PSB3 (+6V dc Regulator) — K32 N/O
YA711 YA411 Pick K22 (+6V Sense) — PSA3/PSB3 dc Regulator Output
YA411 Pick K34 (Sequence -3V) — K9 N/O or K11 N/O and K14 N/C; K22 N/O
A Select Select A/B B Select
YA711 Supply Input Power to PSA1 (+3V dc Regulator) — K34 N/O
YA711 Supply Input Power to PSB1 (+3V dc Regulator) — K34 N/O
YA711 YA411 Pick K21 (+3V Sense) — PSA1/PSB1 dc Regulator Output
YA411 Pick K33 (Sequence +48V) — K9 N/O or K11 N/O and K21 N/O; K14 N/C
A Select Select A/B B Select
YA711 Supply Input Power to PSA2 (+48V dc Regulator) — K33 N/O
YA711 Supply Input Power to PSB2 (+48V dc Regulator) — K33 N/O
YA711 YA411 Pick K24 (+48V Sense) — PSA2 dc Regulator Output; K9 N/O
YA711 YA411 Pick K24 (+48V Sense) — PSB2 dc Regulator Output; K11 N/O
YA211 YA421 Pick K13 (Sequence Complete) — K6 N/O, A Select, K7 N/O, K24 N/O, K10 N/O, and K2 N/O (in A C/I)
YA211 YA421 Pick K13 (Sequence Complete) — K6 N/O, B Select, K8 N/O, K24 N/O, K12 N/O, and K2 N/O (in B C/I)
YA421 YA611 Turn On Sequence Complete Indicator — K6 N/O; Select A/Select B; K13 N/O; K24 N/O; K22 N/O; K21 N/O; K19 N/O; K17 N/O
YA411 YA611 Turn Off Power Check Indicator — K13 N/C; K14 N/O
YA411 GC031 Power-On Reset Signal to System Console Circuit Logic — K13 N/O
Power is now completely sequenced up and logic circuitry is fully conditioned for system operation

●Figure 7-10. SC Power-On Flowchart

setting for the K5 delay, therefore, would be approximately 5 seconds longer than the setting for K6 (power-on delay). Note that these three relays use the +25V dc from the converter/inverters. These filtered supplies provide more reliable operation of time delay relays than the unfiltered +24V supply.

The power supplies in the 2821 Control Unit are the first power supplies to sequence on. This sequencing starts, when POWER ON is pressed and is completed before the K6 time delay relay times out. The circuit to start this sequence is from the +24V supply in the 2821, to the SC, through the POWER ON pushbutton, and back to the 2821 power pick relay. Sequencing the 2821 power on first allows all 2821-to-SC interface lines to reach a quiescent state before the SC circuits are effective.

After K6 (power-on time delay) has timed out, its points transfer to complete a pick circuit for K4 (blowers and SCR transformer). With contactor K4 picked, 208V ac power is supplied to the various gate and power tub blowers, to SCR transformer PS3, and to the 1052 printer associated with the SC (Figure 7-7).

The K6 N/O points also provide a pick circuit for K11 (sequence B power). This circuit is through K6 N/O, the POWER SUPPLY SELECT switch set to B, K16 N/O points, and K7 N/C points. The K16 (high thermal) points prevent power from sequencing on under a high thermal (overtemperature) condition; the K7 (A power on) points provide control while switching from one power supply to the other.

When K11 (sequence B power) picks, a circuit is completed to pick contactor K1 (B power contactor) and relay K8 (B power on). Contactor K1 (Figure 7-1) provides input power to the B C/I. The three main points of K1 gate 208V ac power; the fourth set of points gates 28V ac power. The 28V input is to time delay relay K2 in the C/I. Surge resistors within the C/I prevent damage to the C/I capacitors by limiting and dissipating initial surge currents. After this initial surge period, K2 picks and fires a SCR to short this resistance from the circuit.

The B C/I has input power and its 2500-Hz output is available to the dc regulators when their respective contactors are picked (Figure 7-8). The +25V dc bias voltage is supplied from the B C/I through the K12 N/C points (Figure 7-7).

The actual sequencing of dc voltages begins with the pick of K31 (sequence -3V) through the K11 N/O and K14 N/C points. Contactor K31 completes the input circuit to provide 2500-Hz input power into PSB4. Note that the K31 points also complete the input circuit to PSA4 (Figure 7-8). This latter circuit causes no problem because the A C/I is not active at this time. When the PSB4 output voltage reaches its operating level, the initial part of the sequence is complete and K19 (-3V sense) picks.

Contactor K32 (sequence +6V) now picks through the K11 N/O, K14 N/C, and K19 N/O points. The K32 points gate C/I power into PSB3 (a +6V dc regulator). When the PSB3 output voltage reaches its operating level, the second part of the sequence is complete and K22 (+6V sense) picks.

Contactor K34 (sequence +3V) picks through the K11 N/O, K14 N/C, and K22 N/O points. The K34 points gate C/I power into PSB1 (a +3V dc regulator). When the PSB1 output voltage reaches its operating level, the last logic voltage has sequenced on and K21 (+3V sense) picks.

Contactor K33 (sequence +48V) now picks through the K11 N/O, K21 N/O, and K14 N/C points. The K33 points gate C/I power into PSB2 (a +48V dc regulator). When the PSB2 output voltage reaches operating level, the last dc voltage has sequenced on and K24 (+48V sense) picks.

When all dc voltages have sequenced on, a circuit is complete to pick K13 (sequence complete). This pick circuit is through K6 N/O (power-on delay), the power supply select switch set to B, K8 N/O (B power on), an isolation diode, K24 N/O (+48V sense), the K13 coil, K10 N/O (reset A), and K1 N/O (TD relay in the B C/I).

The pick of K13 (sequence complete) causes the following logical functions:

1. Turns on the POWER SEQUENCE COMPLETE indicator on the operator' panel (to the right of the power-on indicator).
2. Turns off the POWER CHECK indicator (at the top center section of the operator's panel).
3. Removes a 'power-on reset' signal to the logic circuitry of the SC.

After the power sequence is complete, K5 (power-on check) times out. When the K5 points transfer, a test is made for sequence complete. If K13 (sequence complete) has not picked, K14 (power fault) picks and power is sequenced off. This sequence is described in a later section.

The SC cannot be programmed into an operational state like the remainder of the major 9020 elements. Therefore, the power sequence and control circuitry is not interlocked and power can be sequenced off at any time by pressing POWER-ON.

Normal Power-Off Sequence

- Power-off sequence is started by pressing POWER-ON.

- SC voltages sequence off first in four groups:
  1. +48V supply
  2. +3V supply
  3. +6V supply
  4. -3V supply

- 2821 Control Unit power supplies sequence off last.

Refer to Figures 7-9 and 7-11. The control circuitry (Figure 7-9) and the description assume that power supply B is used. Figure 7-11 is applicable to either power group.

A normal power-off sequence can be started at any time by pressing POWER ON on the operator's control panel. The SC is not configured into operational states like the other major system elements and is, therefore, not power-interlocked with logic circuitry.

When POWER ON is set to OFF, the circuit to K5 (power-on check), K6 (power-on delay), and K18 (power-on auxiliary) is opened immediately. The K18 N/O points turn off the POWER ON backlight to indicate to the operator that the power-off sequence has been started.

The K6 N/O points open the circuit to K4 (blowers and SCR transformer). The 208V ac is immediately removed from all logic gate and power tub blowers, the SCR trasformer (used to drive the console indicators), and the 1052 printer (directly associated with the SC) (Figure 7-7).

The same K6 N/O points also open the circuit through the POWER SUPPLY SELECT switch to turn off the sequence complete indicator and drop K11 (sequence B power) and K13 (sequence complete). The main function of the K13 points in the power-off sequence is to turn on the POWER CHECK indicator.

The K11 N/O points which open the circuit to contactor K33 (sequence +48V) start sequencing off the dc regulator supplies. When the K33 points open (Figure 7-8), input power is removed from the +48V regulator supply (PSB2) and K24 (+48V sense) drops.

The K24 N/O points open the circuit to K34 (sequence +3V) and input power is removed from the +3V dc regulator supply (PSB1). When this first logic voltage dc regulator supply output decays, its sense relay (K21) drops.

The K21 N/O points open the circuit to K32 (sequence +6V) and input power is removed from the +6V dc regulator supply (PSB3). As a result, K22 (+6V sense) drops.

The K22 N/O points now open the circuit to K31 (sequence -3V) and input power is removed from the last dc regulator supply (PSB4). When this last supply turns off, K19 (-3V sense) drops to indicate that all dc voltages have been removed from the SC logic circuitry.

The K19 N/O points open the hold circuit for K1 (B power contactor) and K8 (B power on). When K8 drops, the 2821 power pick circuit is broken and power is allowed to sequence down at the 2821 Control Unit. When power is sequenced off the SC first, any "noise" pulses on the 2821-to-SC interface lines are prevented from affecting system operation.

When contactor K1 (B power contactor) drops, the main 208V ac power is removed from the B C/I. The 28V ac circuit which was holding K1 and K2 (in the C/I) is also opened so that these two relays can drop. The K1 N/C points complete a circuit to pick K12 (B reset), and the +25V dc bias voltage is removed from the dc regulator supplies (Figure 7-7).

The power-off sequence is now complete. All dc voltages have been removed from the SC. However, +24V dc and +25V dc are still supplied to the power sequence and control circuitry, and +24V dc is supplied to the power interlock (EPO) circuitry.

Existing ac input includes power to the 115V ac convenience outlets, 208V ac to the 1052 printer that is associated with the PAM, and 28V ac to the A and B converter/inverters.

Switching between Power Supplies A and B

- POWER ON pushbutton need not be operated.
- Switching between supplies is performed by the POWER SUPPLY SELECT switch.
- Alternate supply is automatically sequenced on after all voltages have completely sequenced off the original supply.
- Power is not disrupted to 2821 Control Unit.

Switching between power supplies A and B can be accomplished at any time by setting POWER SUPPLY SELECT to the alternate position. When this switching action occurs, a power-off sequence is completed for the active supply before a complete power-on sequence is started for the alternate supply.

Note that the power in the 2821 Control Unit is not affected when only POWER SUPPLY SELECT is used during the switching operation. If, for some reason, POWER ON is also used during the switching operation, the 2821 performs the normal power-off and power-on sequences as described previously.

When switching the power supplies, the blank switch position between select A and select B has the same initial effect as pressing POWER ON twice (Figure 7-9). Passing through this blank position of the POWER SUPPLY SELECT SWITCH DROPS K5 (power-on check), K6 (power-on delay), and K18 (power-on auxiliary), and initiates a normal power-off sequence as described previously.

When POWER SUPPLY SELECT makes contact at the alternate position, POWER ON backlights again to indicate to the operator that a power-on sequence has been started. The SEQUENCE COMPLETE indicator, however, remains off until the new power-on sequence is complete.

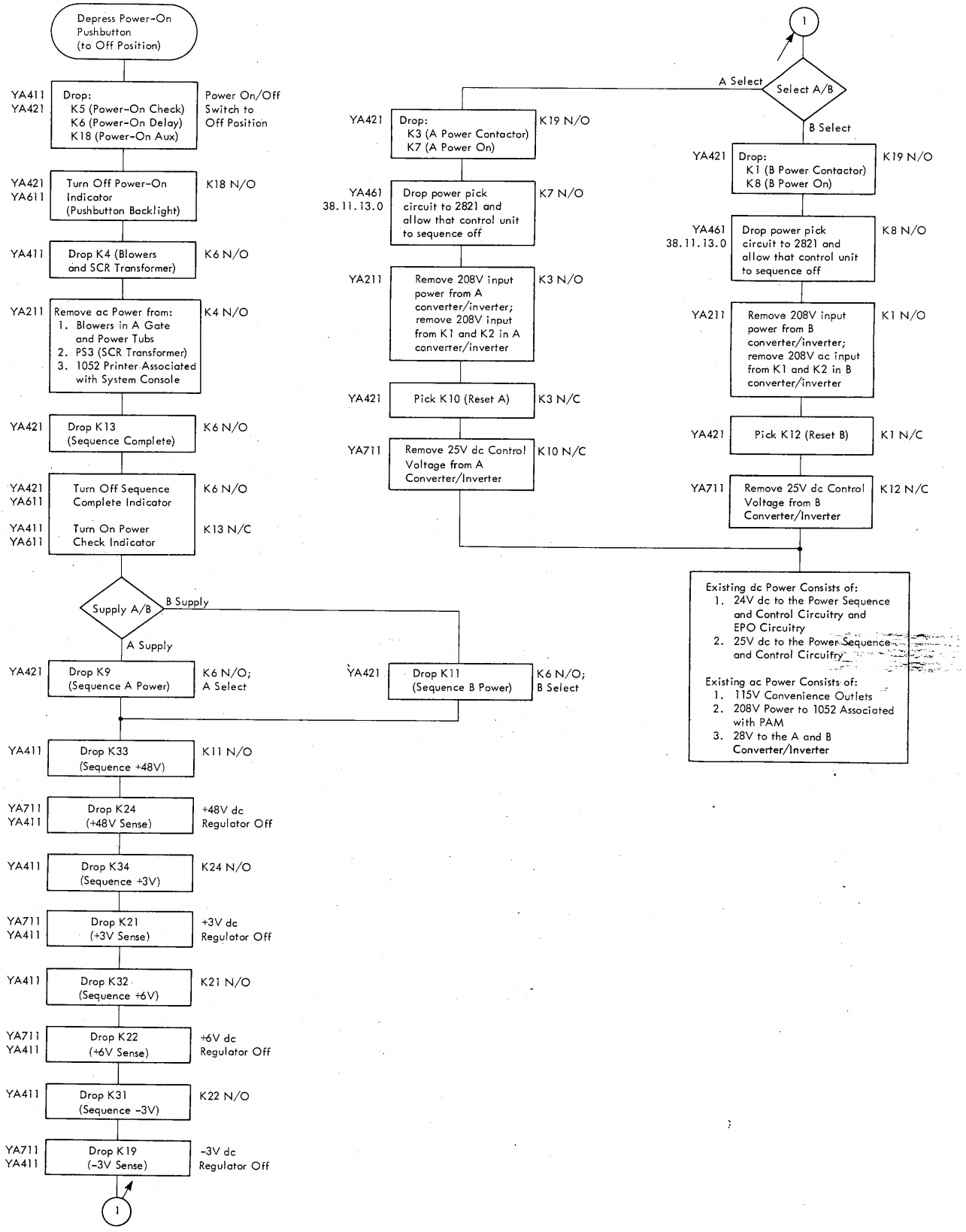

Depress Power-On Pushbutton (to Off Position)
YA411 YA421
Drop: K5 (Power-On Check) K6 (Power-On Delay) K18 (Power-On Aux)
Power On/Off Switch to Off Position
YA421 YA611
Turn Off Power-On Indicator (Pushbutton Backlight)
K18 N/O
YA411
Drop K4 (Blowers and SCR Transformer)
K6 N/O
YA211
Remove ac Power from: 1. Blowers in A Gate and Power Tubs 2. PS3 (SCR Transformer) 3. 1052 Printer Associated with System Console
K4 N/O
YA421
Drop K13 (Sequence Complete)
K6 N/O
YA421 YA611
Turn Off Sequence Complete Indicator
K6 N/O
YA411 YA611
Turn On Power Check Indicator
K13 N/C
Supply A/B
B Supply
A Supply
YA421
Drop K9 (Sequence A Power)
K6 N/O; A Select
YA421
Drop K11 (Sequence B Power)
K6 N/O; B Select
YA411
Drop K33 (Sequence +48V)
K11 N/O
YA711 YA411
Drop K24 (+48V Sense)
+48V dc Regulator Off
YA411
Drop K34 (Sequence +3V)
K24 N/O
YA711 YA411
Drop K21 (+3V Sense)
+3V dc Regulator Off
YA411
Drop K32 (Sequence +6V)
K21 N/O
YA711 YA411
Drop K22 (+6V Sense)
+6V dc Regulator Off
YA411
Drop K31 (Sequence -3V)
K22 N/O
YA711 YA411
Drop K19 (-3V Sense)
-3V dc Regulator Off
1
1
A Select
Select A/B
B Select
YA421
Drop: K3 (A Power Contactor) K7 (A Power On)
K19 N/O
YA461 38.11.13.0
Drop power pick circuit to 2821 and allow that control unit to sequence off
K7 N/O
YA211
Remove 208V input power from A converter/inverter; remove 208V input from K1 and K2 in A converter/inverter
K3 N/O
YA421
Pick K10 (Reset A)
K3 N/C
YA711
Remove 25V dc Control Voltage from A Converter/Inverter
K10 N/C
YA421
Drop: K1 (B Power Contactor) K8 (B Power On)
K19 N/O
YA461 38.11.13.0
Drop power pick circuit to 2821 and allow that control unit to sequence off
K8 N/O
YA211
Remove 208V input power from B converter/inverter; remove 208V ac input from K1 and K2 in B converter/inverter
K1 N/O
YA421
Pick K12 (Reset B)
K1 N/C
YA711
Remove 25V dc Control Voltage from B Converter/Inverter
K12 N/C
Existing dc Power Consists of:
1. 24V dc to the Power Sequence and Control Circuitry and EPO Circuitry
2. 25V dc to the Power Sequence and Control Circuitry
Existing ac Power Consists of:
1. 115V Convenience Outlets
2. 208V Power to 1052 Associated with PAM
3. 28V to the A and B Converter/Inverter

Figure 7-11. SC Power-Off Flowchart

Time delay relays K5 and K6 start their timeout cycle when POWER SUPPLY SELECT makes contact again. The delay setting of these two relays is long enough, however, to allow the previous supply to sequence off before the alternate supplies are sequenced on.

Assume that the B supply is initially selected: K1 (B power contactor) and K8 (B power on) are the last relays in the power-off part of the operation to drop. The K8 N/C points in the circuit for K9 (sequence A power) ensure that the power-on sequence for power supply A is not started until the power-off sequence for power supply B has been completed.

When POWER SUPPLY SELECT was moved from the B select position, K10 (reset A) dropped and immediately started gating the 25V dc bias voltage from the A C/I into the A dc regulator supplies. Therefore, this bias voltage begins conditioning the A supplies during the time that the B supplies are sequencing off. Relay K12 (reset B) cannot pick until K1 (B power contactor) drops at the end of the power-off sequence. The K12 N/C points, therefore, maintain the 25V dc bias voltage from the B C/I to the B dc regulator supplies until those supplies have sequenced off.

During power switching, power is interrupted momentarily to the 1052 printer associated with the SC. Power to the PAM 1052 printer is not affected by the switchover.

Emergency Power-Off Sequence

- An EPO condition immediately removes all prime power.
- Normal power-off sequencing is bypassed.

Pulling the EPO switch on the SC operator's control panel immediately removes all main power beyond the prime power compartment from all 9020 system elements. This EPO switch is a mechanical-latch type switch which must be reset manually.

In the SC, all main power is removed beyond the prime power compartment, except the following:

1. +24V dc still exists within the power interlock circuitry. This voltage is necessary so that power can automatically sequence up when the EPO condition is removed.
2. +25V dc is supplied from the A and B converter/inverters (used to pick the time delay relays in the power sequence and control circuitry).
3. 208V ac is available to contactors K1, K2, and K3 that are associated with the PAM 1052 printer. These contactors are in a second prime power compartment. None of them is picked because their controlling PAM has been turned off as a result of the EPO.

Pulling the EPO switch immediately drops K37 (system master EPO contactor), K2 (console EPO), and K17 (auxiliary EPO). The K37 N/O points open the EPO/MPO circuits to all attached elements (including the SC) and cause those elements to start individual emergency power-off sequences.

In the SC, the three main K2 (console EPO) points remove all 208V ac from the main power area; the fourth set of K2 points removes +24V dc from the power sequence and control circuitry (Figure 7-6). With all power removed, normal power-off sequencing cannot occur and all regulator power starts to fall simultaneously.

The K17 N/O points in the EPO circuitry to the 2821 Control Unit also cause that unit to start an emergency power-off operation. A set of K17 N/O points also opens the circuit to K5, K6, and K18 because the +25V dc is still active from the converter/inverters.

The 208V ac power to the 1052 associated with the SC is interrupted by K2 in the SC. The 208V ac supplied from the SC to the PAM 1052 is interrupted indirectly by the PAM EPO circuitry when the +24V dc from the PAMs drops the contactors in section G (under the 1052 reading board area). This circuitry is on ALD page YA431.

Special Power-Off Sequences

Undervoltage Power-Off Sequence

- Each corresponding pair of A and B power supply dc regulators has a sense relay.
- Undervoltage conditions automatically sequence power off.
- Power is not sequenced on again until:
  1. POWER ON is pressed twice.
  2. The other power supply is selected.

Each corresponding pair of A and B power supply regulators has a common sense relay (Figure 7-8). These sense relays ensure that the associated regulator has an output for SC operation.

When K13 (sequence complete) picks after the power-on sequence has been completed, a K13 N/O point establishes a test circuit for each sense relay (Figure 7-9). If any sense relay drops, the SEQUENCE COMPLETE indicator is turned off by the corresponding N/C points, and the N/O points complete a circuit to pick K14 (power fault). Relay K14 establishes a hold circuit through its N/O points, the POWER SUPPLY SELECT switch, and K16 N/C points.

The power-off sequence is started when the K14 N/C points open the circuits for K31 through K34. Just how

much of a normal power-off sequence occurs depends on which one of the sense relays has dropped. For example, if K24 (+48V sense) has dropped, a normal power-off sequence occurs with the drop of K33 (sequence +48V) and K34 (sequence +3V). When any of the other sense relays drops, a normal power-off sequence is started from that point in the cycle.

After power has sequenced off, K5, K6, and K18 remain picked because the POWER ON switch is still on. The K18 (power-on auxiliary) N/O points keep the POWER ON backlight indicator on to indicate that POWER ON is still on. The K6 (power-on delay) N/O points maintain a hold for K11 (sequence B power) and K14 (power fault). The K14 N/C points open the pick circuit for K1 (B power contactor) and K8 (B power on) to prevent power from immediately recycling on again.

To restore power, K14 (power fault) must be dropped. This may be done in either of two ways, depending on which power supply is used. If the same power supply is used, pressing POWER ON twice drops K6 (power-on delay) and starts the time delay cycle. The K6 N/O points drop K14 (power fault) and allow a pick circuit to be re-established for K1 and K8.

If the alternate supply is needed, the POWER SUPPLY SELECT switch is used. The blank switch position between select A and select B causes K5, K6, and K18 to drop momentarily with the same effect as described previously.

Overvoltage/Overcurrent Power-Off Sequence

- Each dc regulator has an OV/OC sense relay.
- An OV/OC condition automatically sequences power off.
- Power is not sequenced on again until:
  1. The OV/OC condition is reset and POWER ON is pressed twice.
  2. The other power supply is selected.

Each System Console dc regulator has an OV/OC sense relay. If an OV/OC condition occurs in a given regulator, its respective sense relay (a reed relay on the OV/OC SMS card) is picked. The N/O RR contacts (Figure 7-9) of any of the picked relays pick K14 (power fault). The K14 N/C points open the circuit to K33 (sequence +48V) and a normal power-off sequence is started.

After power has sequenced off K5, K6, and K18 remain picked because POWER ON is still on. As described under "Special Power-Off Sequence", K14 (power fault) remains held through the K6 N/O points and the POWER SUPPLY SELECT switch. The K14 N/C points open the pick circuit for K1 (B power contactor) and K8 (B power on) to prevent power from immediately recycling again.

Power may be restored to the SC by using either the same or alternate power supplies. If the same power supply (supply B) is used, the OV/OC condition must be reset manually at the C/I and POWER ON must be pressed twice.

Pressing RESET at the C/I drops the OV/OC reed relay at the regulator. The RR N/O points open the initial pick (and hold) circuit for K14 (power fault). When POWER ON is pressed the first time, K6 (power-on delay) drops and opens the other hold circuit for K14. When POWER ON is pressed a second time, K6 begins its timeout cycle and starts the normal power-on sequence.

If the OV/OC condition is not reset before POWER ON is operated, K14 (power fault) repicks through the RR N/O points when K6 times out. When RESET is pressed at the C/I, hold RESET for a few seconds. A momentary depression is not enough time to reset the OV/OC reed relay and gives a false impression of a second OV/OC condition.

If the alternate power supply (supply A) is used, only POWER SUPPLY SELECT is operated. The blank position between select A and select B causes K5, K6, and K18 to drop momentarily and begin a new power-on sequence.

Note that the visual indication on the SMS card at the defective regulator is lost when the alternate supply is selected. This occurs when the K12 N/C points open the 25V dc control voltage circuit to the B regulators and allow the reed relay to drop.

Thermal Check Power-Off Sequence

- A high thermal condition immediately sequences power off.
- A low thermal condition does not sequence power off but does turn on a THERMAL check indicator.
- Power is not sequenced on until the high thermal circuitry is restored to its normal state.

Two thermal checks (low and high) can occur in the SC. The first check (low thermal) occurs when the operating temperature in the logic gate is between 120°F and 130°F or the temperature in either power tub is between 130°F and 140°F. When any of these thermal devices opens, K15 (low thermal drops and turns on the THERMAL CHECK indicator on the operator's control panel (Figure 7-9).

A low thermal condition does not start a power-off sequence nor does it transmit a special signal to the EXC program.

The second check (high thermal) occurs when the operating temperature in the logic gate exceeds 130°F or when the operating temperature in either power tub exceeds 140°F. When any of these high thermal devices

opens, K16 (high thermal) drops and starts a normal power-off sequence by opening the circuit to K9 (sequence A power) and K11 (sequence B power).

Note that even though power has sequenced off, K4 (blowers and SCR transformer) remains picked to keep the blowers running in an attempt to cool the overheated area.

To restore power to the SC, the thermal condition must be reset and (assuming the same power supply is used) POWER ON must be pressed twice. A THERMAL RESET pushbutton is provided (to the right of the THERMAL CHECK indicator) to reset the thermal relays. Pressing this pushbutton after the temperature in the overheated unit(s) has fallen below the low thermal setting picks relays K15 and K16 and turns off the THERMAL CHECK indicator. Because K14 (power fault) is also picked during this high thermal condition, POWER ON must be pressed a second time to start the power-on sequence.

If the thermal condition is not reset before POWER ON is operated, the K16 N/O points prevent the pick of either K9 or K11. As a result, no further action occurs until K5 (power-on check) picks and causes a second power fault condition.

Sequence Interlock Power-Off Sequence

- Power is automatically sequenced off if all selected voltages are not completely sequenced up within a specific period of time.

Power at the SC should completely sequence up within a few seconds after the pick of K6 (power-on delay). If, for some reason, the sequence cannot be completed within that time, an automatic normal power-off sequence is started. This power-off sequence is accomplished by K5 (power-on check) which is set for a time delay slightly longer than the time necessary to completely sequence power up.

If power is not completely sequenced up, K13 (sequence complete) is not picked when K5 times out. Under these conditions, K14 (power fault) picks through K13 N/C, K5 N/O, the POWER SUPPLY SELECT switch, and K6 N/O. Relay K14 opens the circuit to K33 (sequence +48V) and the power-off sequence is started.

A new power-on sequence can be started by either switching to the alternate power supply or by pressing POWER ON twice.

CONTROLS AND INDICATORS

The following controls and indicators are associated with System Console power. The controls and indicators are on the operator's control panel and in the prime power area.

Operator's Control Panel

EMERGENCY PULL (EPO) Switch

Pulling the EMERGENCY PULL (EPO) switch causes all 9020 system power to be removed within 2 seconds. However, power is still present in the power compartments of each system element.

Note: The EMERGENCY PULL switch is a mechanical-latch type switch that must be reset manually. After the switch is reset, power is automatically sequenced up on all elements that have their POWER ON/OFF switch set to ON.

POWER SUPPLY SELECT Switch

The POWER SUPPLY SELECT switch selects either power supply A or power supply B. If the switch is operated while dc power is on, the previous supply sequences off and the other supply sequences on. During these sequences, all power checks because of undervoltage, overvoltage, overcurrent, or sequence check conditions are reset automatically.

POWER ON Pushbutton

Pressing POWER ON with power off causes the selected power supplies to sequence on; pressing this pushbutton with power on causes the selected power supplies to sequence off. The backlight behind the pushbutton indicates whether the switch is in the power on or power off position.

THERMAL RESET Pushbutton

Pressing THERMAL RESET picks the thermal relays and turns off the THERMAL CHECK indicator, provided the SC operating temperature has fallen below the thermal temperature.

POWER ON Indicator

The POWER ON indicator provides a backlight to the POWER ON pushbutton. Because POWER ON is a pushbutton, this backlight acts as a visual indication to the operator that POWER ON is on. This indicator does not turn on under EPO conditions or if the POWER SUPPLY SELECT switch is set to the blank (center) position.

POWER SEQUENCE COMPLETE Indicator

The POWER SEQUENCE COMPLETE indicator is on when the power sequence of the SC is complete. This indicator is turned off when any dc supply is turned off.

MAINLINE ON Indicator

The MAINLINE ON indicator is on when ac power is available to the SC and main circuit breaker CB1 is closed. This indicator is independent of the POWER ON push-button but does not turn on under EPO conditions.

THERMAL CHECK Indicator

The THERMAL CHECK indicator is on when the SC operating temperature has exceeded 120°F in the logic gate or 130°F in the power tubs. After the operating temperature has returned to normal, the indicator is turned off by pressing THERMAL RESET, operating the POWER ON pushbutton, or switching power supplies.

POWER CHECK Indicator (System Console)

The POWER CHECK indicator is on when one or more of the following conditions exists in the SC power:

1. A catastrophic power failure has occurred (OV/OC, undervoltage, or sequence check condition).
2. An overtemperature condition has sequenced power off.
3. A normal power-off operation has occurred

Power Check Indicators (Elements)

These individual power check indicators are on when the failing element has a power check or thermal check condition. Each element supplies the +24V dc via the EPO cable.

BATTERY Indicator (System Power)

The BATTERY indicator is on when any system element is switched to battery power. The element supplies the +24V dc to the SC via the EPO cable.

STANDBY Indicator (System Power)

The STANDBY indicator is on when prime power for the system is supplied by the standby power supply (motor generator).

+6M A and +6M B Adjustable Controls

The +6M A and +6M B knobs are used to vary the selected +6V dc power supply (as selected by the POWER SUPPLY SELECT switch). The indicator above each knob is on when the knob is not in its normal position.

Console Voltmeter

The console voltmeter monitors the output of the selected +6V dc power supply.

CALIBRATE Jacks

The CALIBRATE jacks are used to calibrate the system console voltmeter.

Prime Power Panel

Circuit Breakers

CB1 (Mainline): controls the 3-phase, 208V ac, 60-Hz input to the SC from the facility power outlet.

CB2 (Thermal): controls input to the convenience outlet transformer. Ther thermal element allows initial surges to occur without tripping. This thermal element replaces fuses F9 and F10 (Figure 7-2).

CB1 (1052): is in the prime power compartment beneath the reading board and its controls the 208V power to the PAM 1052 Printer Keyboard.

Fuses

F1 through F4: protect the PS2 and PS1 (24Vdc/28Vac) power supplies.

F5 and F6: protect the PS3 (SCR transformer) power supply.

F7 and F8: protect the gate and power tub blowers.

F15 and F16: protect the 1052 printer associated with the SC. Two additional fuses (G-F1 and G-F2) are at the 1052 reading board area and they protect the 1052 printer associated with the PAM.

DS1 and DS2 Indicators

The DS1 and DS2 indicators are on when the PS1 and PS2 power supplies are operating. These indicators are on during an EPO condition.

The Configuration Console (CC) is present in the 9020E system only. All configuration console components and circuits associated with power distribution and control are described in this chapter.

POWER SEQUENCE AND CONTROL

Power Component Locations

- Four panels provide power monitoring and control in the configuration console:
  1. The operator's panel.
  2. The A gate (RCU 1) maintenance panel.
  3. The B gate (RCU 2) maintenance panel.
  4. The D gate (SCCU) maintenance panel.
- A meter is provided on the C gate.
- Power components are located in frames 01 and 02 of the CC.

Figures 8-1 through 8-15 show the various power components and controls in the CC. Figure 8-1 shows the overall layout of the power components in the CC.

The operator's panel (Figure 8-2) provides a variety of controls and indications concerning power. These are all located in area A of the operator's panel (Figure 8-3), except for the RCU power-check indicators. These are located in area B. The items on panel A are:

1. An emergency power-off (EPO) switch (labeled EMERGENCY PULL) for removing power from the 9020E system.
2. An element master power-off (MPO) switch (labeled ELEMENT MPO PULL) for removing power only from the CC.
3. Three POWER ON/OFF switches for starting normal power on/off sequences in each RCU and the SCCU.
4. A POWER SUPPLY SELECT switch for selecting B or C power to the SCCU.
5. Three POWER SEQUENCE COMPLETE indicators to show that power sequence is complete in each RCU and the SCCU.
6. A MAINLINE ON indicator to show that mainline power is available in the CC.
7. A POWER CHECK and THERMAL CHECK indicator for the SCCU.
8. Three I/O INTERFACE DISABLE indicators to show when the I/O interface for the SCCU and each RCU is disabled.
9. Three ENABLE/DISABLE switches to enable/disable the I/O interface for the SCCU and each RCU.
10. A THERMAL RESET pushbutton switch to reset the thermal relays in the SCCU circuitry.
11. System standby (STBY) and BATTERY indicators to show whether the system is on standby or on battery power.

The RCU 1 maintenance panel (gate A) provides the following controls and indications concerning power (Figure 8-4):

1. A POWER ON/OFF switch to start normal power on/off sequences in RCU 1.
2. A TEST/OPERATE switch.
3. Sequence complete (SEQ. COMPL), POWER CHECK, and THERMAL CHECK indicators for RCU 1.
4. A marginal voltage control adjust (MC ADJUST) potentiometer for the RCU 1 +6V supply.
5. An MC ON indicator for the above potentiometer.
6. A TEST indicator.
7. A LAMP TEST pushbutton switch for the indicators on this panel.
8. A THERMAL RESET pushbutton switch.

The RCU 2 maintenance panel (gate B) provides the same controls and indications concerning power as the RCU 1 maintenance panel (Figure 8-4).

The SCCU maintenance panel (gate D) contains the following controls and indicators concerning power (Figure 8-5):

1. A LAMP TEST pushbutton to test the indicators on this panel.
2. Marginal voltage control adjust (MC ADJUST) potentiometers for the SCCU B and C +6V supplies.
3. MC ON indicators for the above potentiometers.

A meter is provided for monitoring all logic dc voltages that reach logic gates A, B, and D in the CC (Figure 8-6); the meter is located on the top of the A1 panel on the component side of C gate. A meter-select switch (labeled GATE VOLTAGE) is provided to select one of the nine possible logic voltages to be checked in the CC. A pair of CALIBRATE jacks are also provided to check the calibration of the meter.

The E prime power area (Figures 8-7 and 8-8) contains the following power components.

1. A 24V dc/28V ac prime power supply (E/PS1).
2. A 7.25V ac SCR supply (E-PS2).
3. Circuit breakers (CB1 and CB2).

4. Contactors
5. Indicating fuses (F1 and F2) and regular fuses (F3 and F4).
6. 115V ac convenience outlets.

The F prime power area (Figures 8-8 and 8-9) contains the same power components as the E prime power area with the exception of the 115V ac convenience outlets and the 115V ac CB (CB2).

Power tubs A, B, C, and D (Figure 8-10) are identical, and each contains the following components:

1. A +3V dc regulator at 40-amp power supply.
2. A -3V dc regulator at 20-amp power supply.
3. A +6V dc regulator at 32-amp power supply.
4. A blower to cool the tub.
5. Thermal sensing switches.
6. CBs in each dc regulator.
7. OV "axe" assemblies in each dc regulator.

Ferro/regulator packages (F/R Pacs) A, B, C, and D (Figure 8-11) each contain identical ferro-regulators that supply the dc regulators in the power tubs with input voltages. Figure 8-12 shows where the prime power areas, F/R Pacs, and power tubs are located in the CC.

Gate C contains several components that concern power (Figures 8-6 and 8-13); namely:

1. The EPO jacks for the various system elements and units (C-E3).
2. The EPO contactors and relays (C-E3).
3. The mercury displacement relays (C-A3).
4. The C and D gate contactors (C-A3).
5. Power sequence and control relays for the RCUs and the SCCU. (C-A1, C-B1, and C-C1).

The 115V stepdown transformer is located immediately behind prime power area E and is shown in Figure 8-14. The E and F line filters are located on the rear panel, outside the E and F prime power boxes, and are shown in Figures 8-14 and 8-15.

Power Interlock Circuitry

- Each 9020E system element and unit is power-interlocked with the CC.
- An EPO condition at the CC immediately removes power from all system elements and units.
- An MPO condition at the CC removes power only from the CC.
- Four separate kinds of EPO circuits are provided for the various elements and units in the 9020E system.

The 9020E power-interlock system (Figure 8-16) is such that power is removed from all system elements and units (including the CC) when the EPO switch is pulled at the CC. Pulling the MPO switch at the CC removes power only from the CC. In effect, system EPO remotely operates the MPO of each element (including the CC) to power down the entire system. Figure 8-16 shows the system power-interlock circuitry. Figure 8-17 shows how the system power interlock connects to the CC power sequence and control circuitry.

The system's EPO circuitry (Figure 8-16) is physically located in the CC but operates independently. Thus, it needs no ac or dc power from the CC to operate and will, in fact, function with the CC powered down. There are four separate types of EPO circuits (Figure 8-16) that connect to the elements and units of the 9020E system as follows: System EPO, 2821 EPO, DAU EPO, and 360 EPO. These circuits all perform the same function (power-interlock the system elements and units) but differ slightly in their circuitry.

The system EPO circuit provides EPO for the CE, IOCE, SE, DE, TCU, and CC. When any of these elements provides +24V dc to the system EPO circuit (through pin 1 of its respective EPO jack) and when the system EPO switch (and remote EPO switch if installed on the system) has not been pulled, EPO contactors E3A1, E3A5, E3B4, and E3B5 pick. The N/O points of E3A1 (system EPO) provide a pick circuit for the MPO contactors in the above-mentioned elements. When the EPO switch is pulled, relays E3A1, E3A5, E4B4, and E3B5 drop, and all elements and units in the 9020E system power down.

Note: If no remote EPO switch is used, remote EPO jack E3C6 must be jumpered between pins 1 and 2.

The 2821 EPO circuit provides EPO for the 2821 Control Unit attached to the 9020E system and uses the N/O points of contactor E3A5 (2821, DAU EPO) in its operation. The 2821 powers down if the system EPO switch is pulled but, unlike the system elements, cannot pick the EPO relays. The 2821 DAU EPO relay is picked by any of the system elements, as previously described.

The DAU EPO circuit provides EPO for the 2701 Data Adapter Unit and is similar in operation to the 2821 EPO circuit in that it uses the EPO circuitry but cannot pick the EPO contactors. It also uses 2821 DAU EPO contactor E3A5.

Twelve 360 EPO circuits are provided in the 9020E system to handle possible expansion and attachment of I/O equipment to the system. These circuits function like the 2821 and DAU EPO circuits, but again use different pins on their EPO jacks. Six of these circuits have pins 2 and 6 jumpered in the CC to provide a 'power-on' signal to the connected unit; the other six do not have these pins jumpered. The 360 EPO circuitry uses relays E3B4 and E3B5 (both 360 EPO).

The CC MPO circuit (Figure 8-17) operates in a manner similar to the other 9020E system elements. If the system EPO switch is not pulled, CC MPO contactors E-K1 and F-K1 pick and allow power to be sequenced up in the three units of the CC. If the system EPO switch is pulled, all MPO contactors in the 9020E elements and units drop (including the CC MPO), and they power-down. If the CC MPO switch is pulled, only the CC powers down, because only E-K1 and F-K1 in the CC drop.

AC Distribution

- Two 208V ac, single-phase, 60-Hz inputs.

- Under normal power-off conditions, the following ac voltages exist:
  1. 208V ac to the two prime power supplies, E/PS1 and F/PS1.
  2. 115V ac to the convenience outlets.
  3. 28V ac from E/PS1 to relays A1D9 (ac sense A) and C1D9 (ac sense B).
  4. 28V ac from F/PS1 to relays B1D9 (ac sense D) and C1E9 (ac sense C).

- Under EPO/MPO conditions, the following ac/dc voltages exist:
  1. 208V ac to the two prime power supplies, E/PS1 and F/PS1.
  2. 28V ac from E/PS1 to relays A1D9 (ac sense A) and C1D9 (ac sense B).
  3. 28V ac from F/PS1 to relays B1D9 (ac sense D) and C1E9 (ac sense C).
  4. 24V dc from E/PS1 and F/PS1 to the system EPO and CC MPO circuitry.

The ac input consists of two separate 208V, single-phase, 60-Hz inputs routed directly from two facility service outlets to the two prime power areas, E and F, in the CC (Figure 8-17). Each 208V ac input is routed into a line filter which removes unwanted electrical noise that might adversely affect the logic circuitry in the CC.

Turning on the mainline circuit breakers (E-CB1 and F-CB1) applies the 208V ac input to the +24V dc/28V ac prime power supplies, E/PS1 and E/PS2. As described in the preceding section, the +24V dc outputs of E/PS1 and E/PS2 are routed to the CC MPO circuitry and system EPO contactor (Figures 8-16 and 8-17). If the EPO switch is closed, E3A1 (system EPO contactor) picks (if not already picked by another element) and provides a pick circuit for E-K1 and F-K1, the console MPO contactors.

E/PS1 and F/PS1 also provide a 28V ac output (Figure 8-17). The 28V ac from E/PS1 picks relays A1D9 (ac sense A) and C1D9 (ac sense B). The 28V ac output from E/PS2 picks relays B1D9 (ac sense D) and C1E9 (ac sense C). These relays are used to sense the drop of the 208V ac inputs and are used in the power-sequencing circuits for the RCUs and the SCCU.

When CC MPO contactor E-K1 picks, 208V ac is routed via CB2 to the 115V ac step-down transformer, O2G-T1, which provides 115V ac to the convenience outlets in the CC.

The pick of E-K1 and F-K1 also routes +24V dc from E/PS1 and F/PS1 to the +24V dc 1 bus and the +24V dc 2 bus, respectively. These two buses are then routed through diodes to power the +24V dc bus. The +24V dc 1 bus is used for RCU 1; the +24V dc 2 bus, for RCU 2; and the +24V dc bus, for the SCCU.

Before further distribution of ac power can occur, contactors E-K2, F-K2, E-K3, F-K3, E-K4, and F-K4 must be picked. The pick of these contactors is part of power-on sequencing, which is described in a later section. A list of these contactors, and the circuits they control, appears in Table 8-1.

Table 8-1. AC Contactors

Contactor	Controls	From	To
E-K2	208vac	E-K1	RCU 1 FR PAC PWR TUB "A" BLOWER GATE "A" BLOWERS
	7.25vac	E/PS2	GATE "A" 7.25vac bus
F-K2	208vac	F-K1	RCU 2 FR PAC PWR TUB "D" BLOWER GATE "B" BLOWERS
	7.25vac	F/PS2	GATE "B" 7.25vac bus
E-K3	208vac	E-K1	CONSOLE "B" FR PAC PWR TUB "B" BLOWER
F-K3	208vac	F-K1	CONSOLE "C" FR PAC PWR TUB "C" BLOWER
E-K4	208vac	E-K1	E/PS2
F-K4	208vac	F-K1	F/PS2

The 7.25V ac supplies, E/PS2 and F/PS2, are ferro-resonant transformers, which provide regulation to their 7.25V ac outputs. These outputs power the indicators and indicator SCRs in the CC.

DANGER
Several hundred volts ac are available in these supplies, so extreme caution must be exercised when working in their hazardous areas.

All power to the CC, except the 24V coming from other system elements and units to the EPO circuitry in the CC, can be removed by opening the mainline CBs (E-CB1 and

F-CB1). The 24V EPO voltage can be removed only by opening the mainline CBs in all system elements and units or by pulling all the EPO plugs in the CC.

DC Distribution

- Four sets of F/R Pac-dc regulators.
- Duplexed power supplies for the SCCU.
- Each dc regulator voltage is relay-sensed.

All dc voltages in the SCCU, except the +24V dc power sequence and control voltages, are obtained from regulators.

There are four sets of F/R Pac-dc regulators in the CC. Two sets are used for RCU 1 and RCU 2 circuitry. The other two sets are used as duplex power for the SCCU circuitry.

The F/R Pac (Figure 8-18) is a ferro-resonant transformer rectifier package that consists of a ferro-resonant transformer with four sets of output windings (one, the 18V winding, is not used in the CC). The output of each set of windings is fullwave-rectified and filtered with capacitors to produce a regulated dc output (±10% regulation). The three dc output voltages of the F/R Pac that are used in the CC are: +3V dc at 45 amp, +3V dc at 45 amp, and +6V dc at 40 amp. Each 3V winding is also used to produce a 3V ac bias that is used in the 3V dc regulators.

The output voltages from the F/R Pac are then routed to three dc regulators (+3V, -3V, and +6V). Each dc regulator has a CB on its input circuit from its F/R Pac. An additional set of points on these CBs is used in the power sequence and control circuitry for the RCUs and SCCU. The dc regulators are the series-regulated type and use an SMS card for sensing and regulator control. The output of each regulator has an overvoltage "axe" assembly directly across it to protect the logic circuits which the regulator supplies.

The "axe" assembly is self-contained and consists of a differential amplifier and an SCR. One side of the differential amplifier is held at a reference voltage level by a zener diode; the other side is fed by the output of the dc regulator. When the reference voltage level is exceeded by the output voltage of the dc regulator, the other side of the differential amplifier conducts and biases on a driver transistor. When this driver transistor conducts, it gates an SCR into conduction. This SCR is directly across the output of the dc regulator and shorts out (or axes) the dc regulator's output. This causes an excessive current draw on the regulator's input and trips its input circuit breaker.

The A and D dc regulator voltages are wired directly to the logic circuitry for RCUs. The two sets of dc regulators (B and C) are duplexed through two mercury displacement relays (A3B3 and A3E3) so that only one set of dc voltages (B or C) is supplying power to the SCCU logic at a given time (Figure 8-19). The selection of dc regulators is determined by the position of the B/C POWER SUPPLY SELECT switch on the CC operator's panel.

Each dc voltage is monitored by a sense relay which controls proper power on and off sequencing in the power sequence and control circuitry for each of the RCUs and the SCCU.

Power-On Sequencing

Three sets of power-on sequencing circuits are contained within the CC: one for the SCCU, one for RCU 1, and one for RCU 2. These are described subsequently. Initial sequencing for these circuits is similar and is described first. Figures 8-20 through 8-22 show the power sequence and control circuitry for the SCCU and the RCUs. The flowcharts for all conditions of power on and off appear in Figures 8-23 through 8-36.

Initial Power-On Sequence

See Figures 8-17 and 8-23. Before a power-on sequence can be started in either of the two RCUs, CB1 (mainline CB) for that RCU's prime power area must be closed. RCU 1 uses E prime power; RCU 2 uses F prime power.

The SCCU can be sequenced up if either prime supply is active, depending upon the setting of the B/C POWER SUPPLY SELECT switch (explained under next heading, "SCCU Power-On").

Neither RCU nor the SCCU can sequence power on if a system EPO or CC MPO condition exists, because E-K1 and F-K1 (the console MPO contactors) control power to all dc regulators and all power sequence and control circuitry.

When the E and F prime supplies are activated by 208V ac input power, their +24V dc outputs pick console MPO contactors E-K1 and F-K1, respectively. The E prime supply 28V ac output picks ac sense relays A1D9 (ac sense A) and C1D9 (ac sense B). The F prime supply 28V ac output picks ac sense relays B1D9 (ac sense D) and C1E9 (ac sense C). These relays are used in power-sequencing of the SCCU and RCUs.

When E-K1 and F-K1 (the CC MPO contactors) are picked, +24V dc is gated from the E and F prime power supplies to the +24V dc 1 bus and +24V dc 2 bus, respectively. These buses respectively supply power to the RCU 1 and 2 power sequence and control circuitry. These two buses are then routed through diodes to power the +24V dc bus. This bus supplies power to the SCCU power sequence and control circuitry. When the +24V dc bus is active, the MAINLINE-ON indicator lights. After the ac

sense relays have been picked and the three +24V dc buses (+24V dc 1 bus, and +24V dc 2 bus) are active, initial power-on sequencing is complete. Further power-on sequencing is described next under "SCCU Power-On" and "RCU Power-On".

SCCU Power-On

- The 2821 sequences power-on with the SCCU.
- The SCCU has duplexed power and simplex controls.

See Figures 8-20 and 8-24 for the SCCU power sequence and control circuitry and the SCCU power-on flowchart.

When the +24V dc bus is active (see heading entitled "Initial Power-On" for explanation), the SCCU can begin its power-on sequence. This sequence follows the flowchart in Figure 8-24 after power is up on the +24V dc bus. Initially the THERMAL CHECK indicator is on for such a short period of time that it appears to remain off.

When the SCCU POWER ON/OFF switch is turned on, the 2821 Control Unit attached to the 9020E system starts powering on, because one set of contacts on the SCCU POWER ON/OFF switch are attached to the remote powering circuits in the 2821. However, the 2821 does not power on if its LOCAL/REMOTE switch is in the LOCAL position.

The SCCU sequences power-on with either the B or C power supplies, depending upon the position of the B/C POWER SUPPLY SELECT switch on the operator's panel.

A power-on sequence with the B/C POWER SUPPLY SELECT switch in the B position will be discussed next; but, with the aid of the SCCU power sequence and control diagram (Figure 8-20) and the SCCU power-on flowchart (Figure 8-24), a power-on sequence with the B/C POWER SUPPLY SELECT switch in the C position can be understood.

The SCCU POWER ON/OFF switch provides a pick circuit for mercury displacement relay A3B3, and relay C1A7. The contacts of A3B3 (the mercury displacement relay) select the B dc regulators to power the SCCU logic circuitry (Figure 8-20). The C1A7 relay contacts interlock the C power so that it cannot be brought up while the SCCU is on B power. Next, a pick circuit is provided for contactors A3B1, E-K3, and E-K4. The N/O points of A3B1 select 208V ac from E-K3 (Figure 8-17) to power the C and D logic gate blowers. They also select the E/PS2 7.25V ac supply to power the SCCU SCR indicator drivers. When E-K3 picks, its N/O contacts gate 208V ac to the SCCU B F/R Pac, the B power tub blower, and the C and D logic gate blowers via the contacts of A3B1.

The E-K4 N/O contacts provide 208V ac to E/PS2, the 7.25V ac SCR supply. When the 7.25V ac output of E/PS2 comes up (may already be up from an RCU 1 power-on sequence), it is gated, via the contacts of A3B1, to the SCCU SCR indicator drivers.

As the B F/R Pac comes up, it supplies voltage to the three dc regulators in power tub B. When the outputs of these regulators come up (+3V dc, -3V dc, and +6V dc), they are routed, via the mercury displacement relay points (A3B3), to the SCCU logic circuitry and to SCCU dc sense relays C1A9 (+6V sense), C1B9 (-3V sense), and C1C9 (+3V sense).

When these three dc sense relays pick, their contacts turn off the SCCU POWER CHECK indicator and pick C1C8 (power-on reset). The N/O contacts of C1C8 provide a 'power-on reset' line to the SCCU logic circuitry. They also provide a pick circuit for C1A8 (power-fault interlock).

The N/O contacts of C1A8 pick C1D8 (thermal reset) and C1A6 (driver gate) and also turn on the SCCU POWER SEQUENCE COMPLETE indicator.

When C1D8 picks, it opens the auto reset circuit to the thermal relays. These relays are being held through their respective N/O points and remain picked until the operating temperature within the SCCU circuitry rises to the level that opens one of the relay circuits. The C1A6 N/O contacts gate the driver circuits in the SCCU logic circuitry.

To enable the I/O interface attached to the SCCU, the SCCU ENABLE/DISABLE switch must be placed in the ENABLE position. A disabled I/O interface condition is indicated by a lamp (DISABLE) on the SCCU power section of the operator's panel.

The SCCU cannot be programmed into an operational state like other major elements of the 9020E system. Therefore, the SCCU POWER ON/OFF switch is not power-interlocked, and power can be sequenced off at any time by operating the SCCU POWER ON/OFF switch.

RCU Power-On

- The RCU POWER ON/OFF switches can be power-interlocked.

See Figure 8-21 for RCU 1 power sequence and control circuitry and Figure 8-22 for RCU 2 power sequence and control circuitry. See Figure 8-25 for the RCU 1 power-on flowchart and Figure 8-26 for the RCU 2 power-on flowchart.

RCU 1 and 2 power-on sequencing and circuitry are alike, though with differently named relays and different power supplies. RCU 1 power-on sequence is discussed below, but power-on sequencing for RCU 2 can also be understood from the discussion.

When the +24V dc 1 bus comes up, the RCU 1 POWER CHECK and THERMAL CHECK indicators light. The thermal relays (A1E7 and A1F7) pick through the thermal

sense switches and the N/C contacts of A1D8. When the thermal relays pick, they turn off the RCU 1 THERMAL CHECK indicator. The thermal relays pick fast enough so that the THERMAL CHECK indicator appears to remain off.

Next, both RCU 1 POWER ON/OFF switches are turned to the ON position. These switches are in series, and they provide a pick circuit for E-K2 (RCU 1 power-on) and E-K4 (SCR power-on). However, E-K4 may already be picked if the SCCU is powered up with B power. E-K4 can be picked either by an RCU 1 power-on sequence or an SCCU power-on B sequence.

When E-K2 picks, its N/O contacts (Figure 8-17) gate 208V ac to:

1. The RCU 1 (A) F/R Pac.
2. The A power tub blower.
3. The A logic gate blowers.

The N/O points of E-K2 also provide a gate for the E/PS2 7.25V ac power to the RCU 1 (A gate) SCR indicator drivers.

The E-K4 N/O contacts provide 208V ac to E/PS2, the 7.25V ac SCR supply. When the 7.25V ac output of E/PS2 comes up (may already be up from an SCCU power-on sequence), it is gated, via the E-K2 contacts, to the RCU 1 SCR indicator drivers.

As the A F/R Pac comes up, it supplies voltage to the three RCU 1 (A) dc regulators. When the outputs of these regulators come up (+6V dc, -3V dc, and +3V dc), they supply the RCU 1 (A) logic gate with power and pick dc sense relays A1A9 (+6V sense), A1B9 (-3V sense), and A1C9 (+3V sense). When these three relays pick, their contacts pick A1C8 (power on reset). The N/C contacts of A1C8 turn off the RCU 1 POWER CHECK indicators. The N/O contacts of A1C8 provide a 'power-on reset' line to the RCU 1 logic circuitry and also provide a pick circuit for A1A8 (power-fault interlock).

The N/O contacts of A1A8 pick A1D8 (thermal reset) and driver gate relays A1A6, A1B6, A1C6, A1D6, and A1E6, and also turn on the RCU 1 POWER SEQUENCE COMPLETE indicators.

When A1D8 picks, it opens the auto-reset circuit to the thermal relays. These relays are being held through their respective N/O points and remain picked until the operating temperature within the RCU 1 circuitry rises to the level that opens one of the relay circuits. The driver gate relay contacts gate the driver circuits in the RCU 1 logic circuitry.

To enable the RCU 1 I/O interface, the RCU 1 ENABLE/DISABLE switch on the operator's panel must be switched to the ENABLE position, and the TEST/OPERATE switch on the RCU 1 (gate A) maintenance panel must be switched to the OPERATE position. This action picks A1F6 (enable/disable) and enables the RCU 1 I/O interface. An RCU 1 interface disabled condition is indicated when the DISABLE indicator is lit on the RCU 1 power section of the operator's panel.

With the TEST/OPERATE switch in OPERATE and with any state besides state zero being active in the RCU, relay A1F9 (power interlock) picks and effectively disables the RCU 1 POWER ON/OFF switches by providing a parallel circuit for them. Power cannot be removed until A1F9 drops; to drop this relay, RCU 1 must be in state zero and test.

Normal Power-Off Sequences

Power-off sequences for the SCCU and the RCUs are described separately below.

SCCU Normal Power-Off Sequence

- The 2821 powers-off with the SCCU.

Refer to Figures 8-17, 8-20, and 8-27. The SCCU power-off sequence is similar for a B or C power-off sequence. A normal SCCU power-off with B power is discussed below, but the action for a normal power-off on C power can be understood by following Figures 8-27 (SCCU Normal Power-Off Sequence Flowchart) and 8-20 (SCCU Power Sequence and Control Circuitry).

The normal SCCU power-off sequence is started by turning the SCCU POWER ON/OFF switch to OFF. The 2821 Control Unit attached to the CC will start powering down at this time if the LOCAL/REMOTE switch in the 2821 is in REMOTE. One set of contacts on the SCCU POWER ON/OFF switch is attached to the 2821 remote powering circuit (Figure 8-20).

In the SCCU, several things happen almost simultaneously because the SCCU POWER ON/OFF switch was turned to OFF. The SCCU POWER SEQUENCE COMPLETE indicator turns off, C1A6 (driver gate) drops, C1F6 (enable/disable) drops, C1D8 (thermal reset) drops, E-K3 (console B power-on) drops, A3B1 drops, and, if RCU 1 power is off, E-K4 (SCR power-on) drops. RCU 1 provides a parallel pick circuit for E-K4, and if either RCU 1 or SCCU B power is sequenced up, E-K4 picks. However, both RCU 1 and SCCU B power must be off for E-K4 to drop.

When C1A6 (driver gate) falls, it degates the driver circuits in the SCCU logic gates. The fall of C1F6 (enable/disable) disables the I/O interface attached to the SCCU. Dropping C1D8 (thermal reset) provides an auto-reset circuit to the thermal relays for the next SCCU power-on sequence.

When E-K3 (console B power-on) drops, its contacts (Figure 8-17) open 208V ac to the console B F/R Pac, the

power tub B blower, and the C and D logic gate blowers.

Dropping A3B1 removes 7.25V ac from E/PS2 to the SCR indicator drivers in the SCCU.

If E-K4 drops (RCU 1 power is off), its contacts drop 208V ac to E/PS2 (7.25V ac SCR indicator driver supply). The fall of E/PS2 removes 7.25V ac from the SCR indicator drivers in the SCCU logic circuits.

When the B F/R Pac outputs drop, input power to the B dc regulators is removed and the outputs of these regulators fall (+6V dc, -3V dc, and +3V dc). This removes logic voltages from the SCCU logic gates and drops dc sense relays C1A9 (+6V sense), C1B9 (-3V sense), and C1C9 (+3V sense). When these relays drop, their contacts turn the SCCU POWER CHECK indicators on and drop A3B3 and C1A7. They also drop C1C8 (power on reset). The SCCU power-off sequence is now complete.

RCU Normal Power-Off Sequence

- RCU must be in state zero and test to initiate a normal power-off sequence.

Refer to Figures 8-17, 8-21, and 8-28. The RCU 1 and 2 power-off sequences are alike, but use separate circuits. Only the RCU 1 power-off sequence is discussed in this section, but an RCU 2 normal power-off sequence can be understood by following Figures 8-29 (RCU 2 Normal Power-Off Sequence Flowchart) and 8-22 (RCU 2 Power Sequence and Control Circuitry).

To perform a normal power-off sequence in RCU 1, the TEST/OPERATE switch on the RCU 1 maintenance panel must be placed in TEST. This action drops A1F6 (enable/disable), which disables the I/O interface attached to RCU 1. RCU 1 must be in state zero and the TEST/OPERATE switch must be in TEST to drop A1F9, the power interlock relay. The contacts of A1F9 provide a parallel circuit for the RCU 1 POWER ON/OFF switches, and, if A1F9 is not dropped, the RCU 1 POWER ON/OFF switches are not effective.

When A1F9 drops, a normal power-off sequence can be started by turning either of the RCU 1 POWER ON/OFF switches to OFF. Turning either switch off causes the following to happen almost simultaneously. The RCU 1 POWER SEQUENCE COMPLETE indicators are turned off; driver gate relays A1A6, A1B6, A1C6, A1D6, and A1E6 drop; A1D8 (thermal reset) drops; A1A8 (power fault interlock) drops; E-K2 (RCU 1 power-on) drops; and, if SCCU B power is off, E-K4 (SCR power-on) drops. SCCU B power provides a parallel pick circuit for E-K4, and, if either SCCU B power or RCU 1 power is sequenced up, E-K4 picks. However, both RCU 1 and SCCU B power must be off for E-K4 to drop.

When the driver gate relays drop, they degate the driver circuits in the RCU 1 logic gates. Dropping A1D8 (thermal reset) provides a pick circuit to the thermal relays for the next RCU 1 power-on sequence.

When E-K2 (RCU 1 power-on) drops, its contacts (Figure 8-17) open 208V ac to: the RCU 1 (A) F/R Pac, the A power tub blower, and the A gate blower. They also open the 7.25V ac line from E/PS2 (7.25V ac SCR supply) to the SCR indicator drivers in the RCU 1 (A gate) logic circuitry.

If E-K4 drops (SCCU B power is off), its contacts drop 208V ac to E/PS2, the 7.25V ac SCR indicator driver supply.

When the A F/R Pac outputs drop, input power to the A (RCU 1) dc regulators is removed and the outputs of these regulators fall (+6V dc, -3V dc, and +3V dc). This removes logic voltages from the RCU 1 logic gate (gate A) and drops dc sense relays A1A9 (+6V sense), A1B9 (-3V sense), and A1C9 (+3V sense). When these dc relays drop, their contacts turn the RCU 1 POWER CHECK indicators on and drop A1C8 (power-on reset). The RCU 1 normal power-off sequence is now complete.

SCCU B/C Supply Switchover

- The SCCU POWER ON/OFF switch need not be operated.
- Switching between supplies is accomplished by the B/C POWER SUPPLY SELECT switch.
- The alternate supply is automatically sequenced on after all voltages have sequenced off in the original supply.
- Power to the 2821 Control Unit is not disrupted.

Refer to Figures 8-17, 8-20, and 8-30. Switching between power supplies B and C in the SCCU can be accomplished at any time by setting the B/C POWER SUPPLY SELECT switch to the alternate position. When this switching action occurs, a power-off sequence is completed for the active supply before a complete power-on sequence is started for the alternate supply. Note that the 2821 Control Unit is not affected when only the B/C POWER SUPPLY SELECT switch is used during the switching operation. If, for some reason, the SCCU POWER ON/OFF switch is also used during the switching operation, the 2821 performs the normal power-off and power-on sequences described previously.

When the power supplies are switched, the blank position between B and C (Figure 8-20) has the same initial effect as turning the SCCU POWER ON/OFF switch to OFF. Passing through this blank position starts a normal power-off sequence in the SCCU, and the SCCU POWER SEQUENCE COMPLETE indicator turns off.

When relays A3B3, and C1A7 (if B power was active at switchover) drop, a new power-on sequence is immediately started with C power. When the C power-on sequence is complete, the SCCU POWER SEQUENCE COMPLETE indicator again lights.

Emergency Power-Off Sequence

- An EPO or MPO condition immediately removes all prime power.
- Normal power-off is bypassed.

Pulling the EPO switch on the CC operator's panel immediately removes all main power beyond the prime power compartment from all 9020E system elements. Pulling the MPO switch on the CC removes all main power (beyond the prime power area) from only the CC. These EPO and MPO swithes are mechanical-latch types which must be reset manually.

Pulling the system EPO switch (Figure 8-16) immediately drops E3A1 (system EPO), E3A5 (2821, DAU EPO), E3B4 (360 EPO), and E3B5 (360 EPO). Their contacts open the MPO circuits in all attached elements (including the CC) and cause those elements to start individual emergency power-off sequences. When E3A1 (system EPO) drops, its contacts open and drop MPO contactors E-K1 and F-K1 in the CC. Pulling the CC MPO switch also opens the circuit for E-K1 and F-K1 in the CC but does not affect any other 9020E system elements or units.

When E-K1 and F-K1 drop, 208V ac is removed from all power supplies except the E and F 24V dc/28V ac prime power supplies (Figure 8-17). Also, when E-K1 and F-K1 drop, 24V dc from the prime supplies is removed from all power sequence and control circuitry. With all 208V ac power removed from the fans and regulators, normal power-off cannot occur and all power falls simultaneously. 24V dc still exists in the prime power compartment after an EPO/MPO so that power can automatically sequence-up when the EPO/MPO condition is removed.

Special Power-Off Sequences

Three categories of special power-off sequences are described below. These sequences result from the detection of (1) an undervoltage (UV) condition of a dc regulator, (2) an overvoltage or overcurrent (OV/OC) condition of a dc regulator, or (3) an overtemperature (thermal) condition in a logic gate or power tub.

Undervoltage Power-Off Sequences

- Dc regulators are relay-sensed for undervoltage (UV).

Each dc regulator in the CC is sensed for an undervoltage condition by a sense relay in the power sequence and control circuitry of its respective RCU or SCCU. If an SCCU or RCU dc regulator output voltage drops, its respective dc sense relay falls and initiates a power-off sequence in that RCU or SCCU. SCCU and RCU UV power-off sequences are individually described below.

SCCU Undervoltage Power-Off Sequence

- Each corresponding pair of B and C dc regulators has a sense relay.
- An undervoltage condition automatically sequences power-off.
- Power is not sequenced up again until the SCCU POWER ON/OFF switch is operated or the other power supply is selected with the B/C POWER SUPPLY SELECT switch.

Each corresponding pair of B and C dc regulators has a common sense relay (Figure 8-19). These relays ensure that the associated regulator has an output for SCCU operation.

Refer to Figures 8-17 and 8-20 for SCCU UV power-off sequencing. When the SCCU power-on sequence has been completed, a C1A8 (power-fault interlock) relay contact establishes a test circuit for the dc sense relays (Figure 8-20). If one of these relays drops, its contacts turn on the SCCU POWER CHECK indicator, drop C1C8 (power on reset), and pick C1B8 (power fault) through the above-mentioned test circuit. Assuming a B power-on condition, when C1B8 picks, its contacts open the pick circuit to A3B1 and E-K3 (and E-K4 if RCU 1 power is off); they also drop C1A6 (driver gate) and C1F6 (enable/disable) and turn off the SCCU POWER SEQUENCE COMPLETE indicator.

Dropping A3B1 removes the 7.25V ac from E/PS2 to the SCR indicator drivers for the SCCU.

When E-K3 drops, it opens the 208V ac input to the B F/R Pac, the B power tub blower, and the C and D logic gate blowers. The fall of the B F/R Pac consequently causes the B dc regulators to fall.

When all three dc sense relays are dropped (C1A9, C1B9, and C1C9), their N/O contacts drop C1A8 (power-fault interlock).

The SCCU UV power-off is now complete, with the following SCCU relays remaining picked:

1. Thermal relays C1C7, C1D7, C1E7, and C1F7.

2. C1D8 (thermal reset).
3. A3B3 and C1A7.
4. C1B8 (power fault).

To start a new SCCU power-on sequence, turn the SCCU POWER ON/OFF switch first off and then on or switch the B/C POWER SUPPLY SELECT switch to the opposite position. Power cannot be sequenced on until C1B8 (power fault) has dropped. Either of the actions just described drops C1B8.

RCU Undervoltage Power-Off Sequence

- Each dc regulator has a sense relay.
- An undervoltage condition automatically sequences power-off.
- Power is not sequenced on again until the RCU POWER ON/OFF switch is operated.

Both RCU 1 and 2 sequence power off in a similar manner, but with separate circuitry. A UV power-off sequence for RCU 1 is discussed in this section (Figures 8-17 and 8-21).

When the RCU 1 power-on sequence has been completed, an A1A8 (power-fault interlock) contact establishes a test circuit for the dc sense relays (Figure 8-21). If one of these relays drops, its contacts drop A1C8 (power on reset) and driver gate relays A1A6, A1B6, A1C6, A1D6, A1E6, and A1F6 (enable/disable); turn off the RCU 1 POWER SEQUENCE COMPLETE indicators; and pick A1B8 through the above-mentioned test circuit.

When A1B8 picks, it holds through its own points and drops E-K2 (RCU 1 power on); it also drops E-K4 if SCCU B power is off.

When E-K2 drops, it opens the 208V ac to the A F/R Pac, the power tub A blowers, and the A gate blowers. E-K2 also opens the 7.25V ac from E/PS2 to the RCU 1 (A gate) SCR indicator drivers. The fall of the A F/R Pac consequently causes the A dc regulators to fall.

When the outputs of the RCU 1 dc regulators fall, their dc sense relays A1A9 (+6V sense), A1B9 (-3V sense), and A1C9 (+3V sense) drop. When these relays all drop, they drop A1A8 (power-fault interlock). The fall of A1C8 (power on reset) causes the RCU 1 POWER CHECK indicators to light.

The RCU 1 UV power-off sequence is now complete, with only thermal sense relays A1E7 and A1F7, A1D8 (thermal reset), and A1B8 (power fault) remaining picked.

To again sequence RCU 1 power-up, the RCU 1 POWER ON/OFF switch must first be turned off (to drop A1B8) and then on.

Overvoltage/Overcurrent Power-Off Sequences

Each of the CC dc regulators is equipped with a circuit breaker (CB) in its input circuit from the F/R Pac. An auxiliary set of contacts on this CB is used to sequence power-off in the event of an overcurrent (CB trip) condition. Each dc regulator output circuit is equipped with an overvoltage "axe" assembly.

The axe assembly consists of a differential amplifier and an SCR. One side of the amplifier is voltage-referenced by a zener diode; the other is fed by the regulator output voltage. If this voltage rises above the zener reference level, the amplifier conducts and gates the SCR (axe) into conduction. The SCR is wired across the output of the dc regulator and immediately shorts the regulator's output (axes it). This causes an excessive draw of input current and trips the input CB in the regulator. The OV condition causes an OC condition; the latter causes the power-off sequence.

SCCU and RCU OV/OC power-off sequences are described individually below.

SCCU OV/OC Power-Off Sequence

- Each dc regulator has an OV axe assembly on its output.
- Each dc regulator has a CB in its input circuit.
- An OC condition automatically sequences power-off.
- Power is not sequenced on again until the OC condition is reset and the SCCU POWER ON/OFF switch is operated or the other power supply is selected with B/C POWER SUPPLY SELECT switch.

Refer to Figures 8-17, 8-20, and 8-31. An SCCU OV/OC power-off sequence will be discussed for the SCCU with B power on. An SCCU OV/OC power-off sequence with C power can be understood by following the SCCU OV/OC power-off sequence flowchart (Figure 8-31).

When the input CB trips, its auxiliary contact closes and picks C1B8 (power fault). The C1B8 contacts then turn off the SCCU POWER SEQUENCE COMPLETE indicator and drop C1A6 (driver gate), C1F6 (enable/disable), E-K3 (console power on), A3B1, and E-K4 (SCR power on). However, E-K4 is not dropped if RCU 1 power is up.

At the same time, the dc sense relay (C1A9, C1B9, or C1C9) for the dc regulator that had the OC condition drops. When this happens, its contacts turn on the SCCU POWER CHECK indicator and drop C1C8 (power-on reset).

When E-K3 drops, its contacts remove 208V ac to the B F/R Pac, the B power tub blower, and the C and D logic

gate blowers. The A3B1 contacts remove 7.25V ac from the SCCU SCR indicator drivers.

As the B F/R Pac drops, the remaining B dc regulator outputs drop. When these outputs drop, the remaining dc sense relays drop, whereupon their contacts drop C1A8 (power-fault interlock). The SCCU OV/OC power-off sequence is now complete, and the following SCCU relays remain picked:

1. C1D8 (thermal reset)
2. C1C7, C1D7, C1E7, and C1F7 (thermal relays)
3. C1B8 (power fault)
4. A3B1, A3B3, and C1A7

To again sequence power-on in the SCCU, relay C1B8 (power fault) must be reset. A new power-on sequence can be started in two ways:

1. Reset the tripped dc regulator CB and turn the SCCU POWER ON/OFF switch off (to reset C1B8) and then on.
2. Switch the B/C select switch to its opposite position.

RCU OV/OC Power-Off Sequence

- Each dc regulator has an axe assembly on its output.
- Each dc regulator has a CB in its input circuit.
- An OC condition automatically sequences power-off.
- Power is not sequenced on again until the OC condition is reset and the RCU POWER ON/OFF switch is operated.

Refer to Figures 8-17, 8-21, and 8-32. An OV/OC power-off sequence for RCU 1 is described, but an RCU 2 OV/OC power-off sequence can be understood by following Figures 8-22 and 8-33.

When the input CB trips, its auxiliary contact picks A1B8 (power fault). The A1B8 contacts then turn off the RCU 1 POWER SEQUENCE COMPLETE indicators and drop A1F6 (enable/disable); driver gate relays A1A6, A1B6, A1C6, A1D6, and A1E6; and E-K2 (RCU 1 power-on). If the SCCU B power is off, E-K4 (SCR power-on) is also dropped.

At the same time, the dc sense relay (A1A9, A1B9, or A1C9) for the dc regulator that had the OC condition drops. When this happens, its contacts drop A1C8 (power-on reset). When A1C8 drops, its contacts turn on the RCU 1 POWER CHECK indicators.

When E-K2 drops, its contacts drop 208V ac to the A F/R Pac, the A power tub blower, and the A logic gate blowers.

As the A F/R Pac drops, the remaining dc regulator outputs drop, whereupon the remaining dc sense relays drop. When these relays drop, their contacts drop A1A8 (power-fault interlock).

The RCU 1 OV/OC power-off sequence is now complete, and the following RCU 1 relays remain picked:

1. A1B8 (power fault)
2. A1D8 (Thermal reset)
3. A1E7 and A1F7 (thermal relays)

To again sequence power-on in RCU 1, relay (A1B8) (power fault) must be reset and the OV/OC condition must be corrected. To accomplish these, reset the tripped CB on the dc supply and turn one of the RCU 1 POWER ON/OFF switches off and then on.

Thermal Check Power-Off Sequences

- A catastrophic (high) thermal condition immediately sequences power off.
- A warning (low) thermal condition does not sequence power-off but turns on the THERMAL CHECK indicator.

Two thermal checks (low and high) can occur in the CC. The first check (low or warning thermal) occurs when the operating temperature in the logic gates is between 120°F and 130°F or the temperature in a power tub is between 130°F and 140°F. When one of the low thermal sensors in the RCUs or the SCCU senses a low thermal condition, its contacts open and turn on the THERMAL CHECK indicator for its respective RCU or SCCU.

A low thermal condition does not start a power-off sequence, nor does it transmit a special signal to the EXC program for an SCCU thermal warning. In the RCUs, however, an OTC signal is sent upon the occurrence of a low thermal condition.

To reset the THERMAL CHECK indicators for the respective RCUs and SCCU, the thermal condition must no longer be present and the respective RCU or SCCU THERMAL RESET pushbutton is depressed.

The second check (catastrophic or high thermal) occurs when the operating temperature in the CC exceeds 130°F in a logic gate or the operating temperature in a power tub exceeds 140°F. When one of these conditions occurs, a thermal check power-off sequence is started in the respective RCU or SCCU. SCCU and RCU thermal check power-off sequences are described individually below.

SCCU Thermal Check Power-Off Sequence

Refer to Figures 8-17, 8-20, and 8-34. Assuming the SCCU is on B power, when one of the high thermal switches opens, it breaks the circuit for one of the three high

thermal relays (C1C7, C1D7, or C1E7). With the SCCU operating on B power, C1D7 (the C power tub high thermal relay) cannot cause a thermal check power-down sequence because its contacts are isolated from the power sequence and control circuits by the B/C POWER SUPPLY SELECT switch (Figure 8-20).

If one of the other two high thermal relays drops (C1C7 or C1E7), they start an SCCU power-off sequence by picking C1B8 (power fault) and by dropping A3B1 and E-K3 (console power-on). If the RCU 1 power is off, they also drop E-K4 (SCR power on).

Picking C1B8 drops C1A6 (driver gate) and C1F6 (enable/disable) and turns off the SCCU POWER SEQUENCE COMPLETE indicator.

When A3B1 drops, its contacts open the 7.25V ac from E-PS2 to the SCCU SCR indicator drivers. Dropping E-K3 removes the 208V ac to the B F/R Pac, the power tub B blower, and the C and D logic gate blowers.

As the F/R Pac output drops, the B dc regulators drop. When these regulators drop, their dc sense relays (C1A9, C1B9, and C1C9) drop. The sense relay contacts then drop C1A8 (power fault interlock) and C1C8 (power on reset).

The SCCU thermal check power-off sequence is now complete, and the following relays are still energized:

1. A3B3 and C1A7.
2. C1D8 (thermal reset).
3. The other high thermal relays.

If the high thermal was in the B power tub (C1C7 dropped), power in the SCCU can be sequenced on again by switching the B/C POWER SUPPLY SELECT switch to its opposite position. However, if the high thermal was in the SCCU logic gates (C or D), power cannot be sequenced up until the high thermal condition has cleared. Then the SCCU POWER ON/OFF switch is first turned off (to drop C1B8) and then on.

RCU Thermal Check Power-Off Sequence

Refer to Figures 8-17, 8-21, and 8-35. An RCU 1 thermal check power-off sequence is described in this section, but an RCU 2 thermal check power-off sequence is the same and can be followed with Figures 8-17, 8-22, and 8-36.

When a high thermal sense switch in the A power tub or the RCU logic gate (gate A) opens, it drops relay A1E7 (hi thermal). When A1E7 drops, it picks A1B8 (power fault), drops E-K2 (RCU 1 power-on), and, if SCCU B power is off, it drops E-K4 (SCR power-on).

The A1B8 contacts then:

1. Turn off the RCU 1 POWER SEQUENCE COMPLETE indicators.
2. Drop A1A6, A1B6, A1C6, A1D6, and A1E6 (driver gate relays).
3. Drop A1F6 (enable/disable).

When E-K2 drops, its contacts drop 208V ac to the RCU 1 (A) F/R Pac, the power tub A blower, and the logic gate A blowers. As the F/R Pac output drops, the A dc regulators drop. When these regulators drop, their dc sense relays (A1A9, A1B9, and A1C9) drop. These sense relays drop A1C8 (power on reset) and A1A8 (power-fault interlock). When A1C8 drops, its contacts turn on the RCU 1 POWER CHECK indicators.

The RCU 1 thermal check power-off sequence is now complete, and the following relays are still energized: A1B8 (power fault) and A1D8 (thermal reset).

To again sequence power-on in RCU 1, the high thermal condition must have been cleared. Next, the RCU 1 POWER ON/OFF switch is turned off (to drop A1B8) and then on.

CONTROLS AND INDICATORS

The controls and indicators associated with CC power are located on the operator's panel; the maintenance panels on A, B, and D gates; the C-gate A1 panel; and prime power areas E and F.

Operator's Panel (Figure 8-2)

Descriptions of the controls and indicators concerning power that are located on the operator's panel follow.

EMERGENCY PULL (EPO) Switch

Pulling this switch causes all 9020E system power to be removed within 2 seconds. However, power is still present in the power compartments of each system element.

ELEMENT MPO PULL Switch

Pulling this switch causes all CC power to be removed within 2 seconds. However, power is still present in the two prime power compartments (E and F) and in the system EPO circuitry from the system elements and units.

Note: The EPO and MPO switches are mechanical-latch types that must be reset manually. After the EPO switch is reset, power is automatically sequenced up on all elements that have their POWER ON/OFF switches set to ON. Resetting the CC MPO switch automatically starts a power-on sequence in the CC.

B/C POWER SUPPLY SELECT Switch

This switch selects B or C power for the SCCU circuitry. If the switch is operated while dc power is on, the previous

supply sequences off and the other supply sequences on. During these sequences, all SCCU power checks caused by undervoltage, overvoltage, or overcurrent conditions are automatically reset.

SCCU POWER ON/OFF Switch

This switch starts a power-on/off sequence in the SCCU power sequence and control circuitry.

SCCU POWER SEQUENCE COMPLETE Indicator

This indicator is on when the power sequence of the SCCU is complete. The indicator is turned off when any SCCU dc supply is turned off.

MAINLINE ON Indicator

This indicator is on when mainline power is available in the CC. The indicator turns off under an EPO condition or when both mainline CBs (E-CB1 and F-CB1) are opened.

THERMAL CHECK Indicator

This indicator is on when the SCCU operating temperature has exceeded 120°F in the SCCU logic gates or 130°F in the SCCU power tubs. After the operating temperature has returned to normal, the indicator is turned off by depressing the SCCU THERMAL RESET pushbutton, operating the SCCU POWER ON/OFF switch, or switching power supplies with the B/C POWER SUPPLY SELECT switch.

SCCU POWER CHECK Indicator

This indicator is on when one or more of the following conditions exist in the SCCU power:

1. A catastrophic power failure has occurred (OV/OC or UV).
2. An overtemperature condition has sequenced power-off.
3. A normal power-off operation has occurred.

BATTERY Indicator (SYSTEM POWER)

This indicator is on when any 9020E system element is switched to battery power. The element supplies the 24V dc to the CC via its EPO cable.

STBY (Standby) Indicator (SYSTEM POWER)

This indicator is on when prime power for the system is supplied by a facility standby power source. A remote contact of the facility standby power source is necessary to turn on this indicator. Power for the indicator (+24V dc) is supplied by the CC.

SCCU THERMAL RESET Pushbutton Switch

This pushbutton switch resets a thermal check in the SCCU after the SCCU has returned to correct operating temperature.

SCCU ENABLE/DISABLE Switch

This switch is used to enable/disable the I/O interface attached to the SCCU.

SCCU DISABLE Indicator

This indicator is on when the SCCU I/O interface is in a disabled condition.

RCU 1 POWER ON/OFF Switch

This switch starts a normal power-on/off sequence in the RCU 1 power sequence and control circuitry.

RCU 1 POWER SEQUENCE COMPLETE Indicator

This indicator is on when the power sequence of RCU 1 is complete. The indicator is turned off when any RCU 1 dc supply is turned off.

RCU 1 ENABLE/DISABLE Switch

This switch is used to enable/disable the I/O interface attached to RCU 1.

RCU 1 DISABLE Indicator

This indicator is on when the RCU 1 I/O interface is in a disabled condition.

RCU 2 POWER ON/OFF Switch

This switch starts a normal power-on/off sequence in the RCU 2 power sequence and control circuitry.

RCU POWER SEQUENCE COMPLETE Indicator

This indicator is on when the power sequence of RCU 2 is complete. The indicator is off when any RCU 2 dc supply is turned off.

RCU 2 ENABLE/DISABLE Switch

This switch is used to enable/disable the I/O interface attached to RCU 2.

RCU 2 DISABLE Indicator

This indicator is on when the RCU 2 I/O interface is in a disabled condition.

POWER CHECK Indicators (Elements)

These individual POWER CHECK indicators are on when their corresponding element has a power check, a thermal check, or a normal power-down condition. Each element supplies the +24V dc to the indicator via its EPO cable.

SCCU Maintenance Panel (Figure 8-5)

Descriptions of the controls and indicators concerning power that are located on the SCCU maintenance panel (gate D) follow.

B and C MC ADJUST Potentiometers

These potentiometers are used to vary the +6V dc supplies for SCCU B and C power, respectively. The indicator above each knob is on when the potentiometer is not set to its normal position.

B and C MC ON Indicators

These indicators are on when their corresponding MC ADJUST potentiometers are not set to their normal positions.

LAMP TEST Pushbutton Switch

This pushbutton switch is used to test all of the indicators on this panel.

RCU 1 and RCU 2 Maintenance Panels (Figure 8-4)

These panels are identical in appearance, but one is on A gate and controls RCU 1; the other is on B gate and controls RCU 2. Descriptions of the controls and indicators concerning power that are located on the RCU maintenance panels follow.

POWER ON/OFF Switch

This switch is used to start a normal power-on/off sequence in the respective RCU's power sequence and control circuitry. The switch is wired in series with the respective RCU's POWER ON/OFF switch on the operator's panel.

SEQ COMPL (Sequence Complete) Indicator

This indicator is on when power sequence is complete in its respective RCU. The indicator is wired in parallel with its respective RCU's POWER SEQUENCE COMPLETE indicator on the operator's panel.

POWER CHECK Indicator

This indicator is on when one or more of the following conditions exist in its respective RCU's power:

1. A catastrophic power failure has occurred (OV/OC or UV).
2. An overtemperature condition has sequenced power-off.
3. A normal power-off operation has occurred.

THERMAL CHECK Indicator

This indicator is on when its respective RCU's operating temperature has exceeded 120°F in the logic gates or 130°F in the power tub. After the operating temperature has returned to normal, the indicator is turned off by depressing the RCU THERMAL RESET pushbutton or operating the RCU POWER ON/OFF switch.

THERMAL RESET Pushbutton Switch

This pushbutton switch is used to reset a thermal check in its respective RCU after the operating temperature in that RCU has returned to normal.

MC ADJUST Potentiometer

This potentiometer is used to vary the +6V dc supply for its respective RCU. The indicator above this potentiometer is on when the potentiometer is not set to its normal position.

MC ON Indicator

This indicator is on when the MC ADJUST potentiometer below it is not set to its normal position.

TEST/OPERATE Switch

This switch must be in TEST position to drop the power-interlock relay and allow a normal power-off in the respective RCU.

LAMP TEST Pushbutton Switch

This pushbutton switch is used to test the indicators on this panel.

Gate C, A1 Panel (Figure 8-6)

Descriptions of the controls concerning power that are located on the C-A1 panel follow.

Voltmeter

The voltmeter is used to monitor the logic voltages in A, B, and D gates. The voltage that is to be monitored is selected by the GATE VOLTAGE select switch. The +3V dc, -3V dc, and +6V dc on A, B, and C gates can be monitored on this meter.

CALIBRATE Jacks

These jacks are used to calibrate the voltmeter against an external meter.

GATE VOLTAGE Select Switch

This switch is used to select one of nine voltages from A, B, and D gates to the voltmeter.

Prime Power Box E (Figure 8-12)

Prime power box E contains CBs and fuses that are described below.

Circuit Breakers

CB1 (Mainline): controls the one-phase, 208V ac, 60-Hz input to prime power area E from the facility service outlet.

CB2 (Thermal): controls input to the convenience outlet transformer. The thermal element allows initial surges to occur without tripping.

Fuses

F1 and F2: protect the E/PS1 (24V dc/28V ac) prime power supply. These are indicating fuses. F3 and F4 protect the E/PS2 (7.25V ac) indicator power supply.

Prime Power Box F (Figure 8-12)

Prime power box F contains CBs and fuses that are described below.

Circuit Breaker

CB1 (Mainline): controls the single-phase, 208V ac, 60-Hz input to prime power area F from the facility service outlet.

Fuses

F1 and F2: protect the F/PS1 (24V dc/28V ac) prime power supply. These are indicating fuses.

F3 and F4: protect the F/PS2 (7.25V ac) indicator power supply.

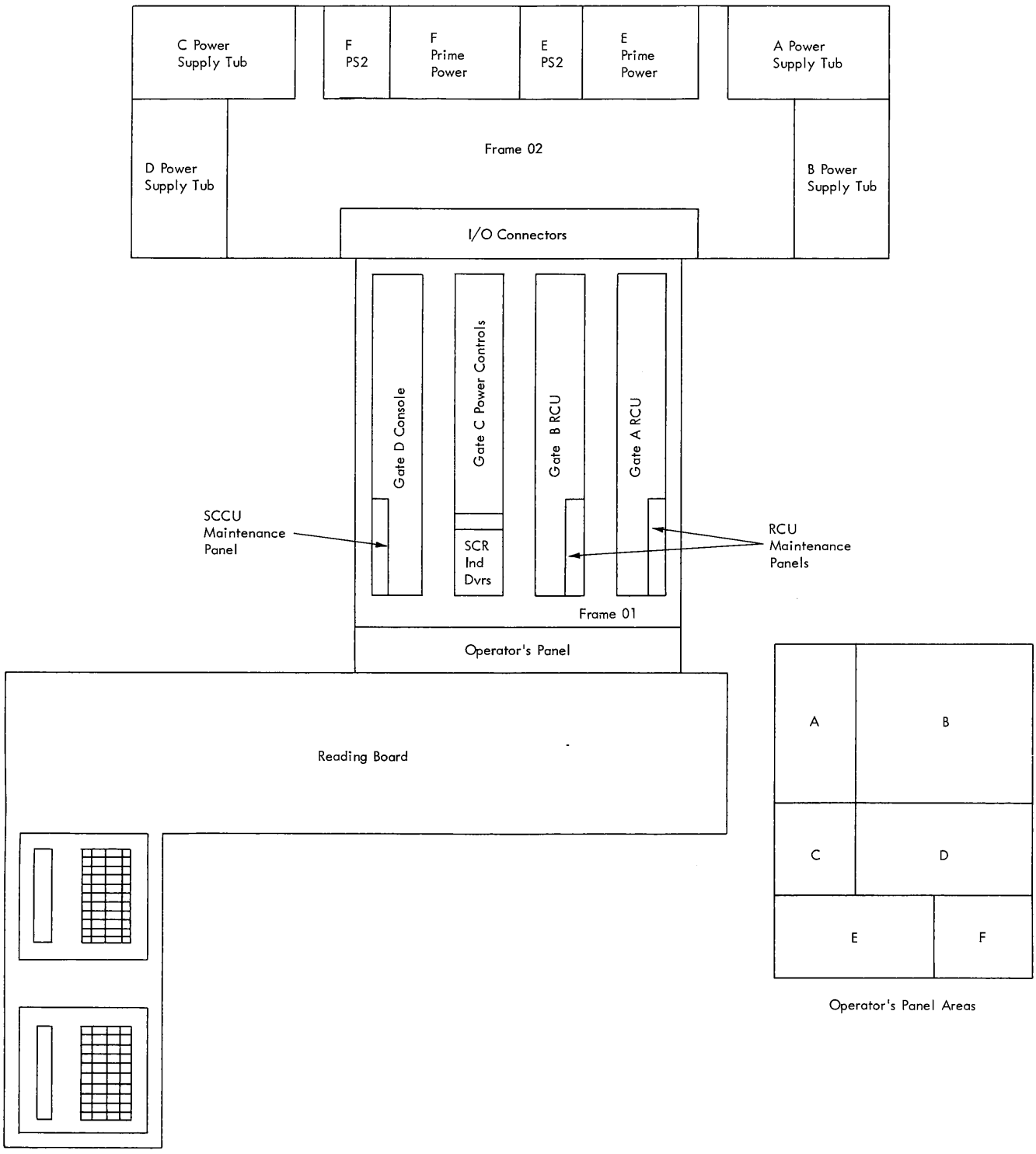


Figure 8-1. Configuration Console (Top View)

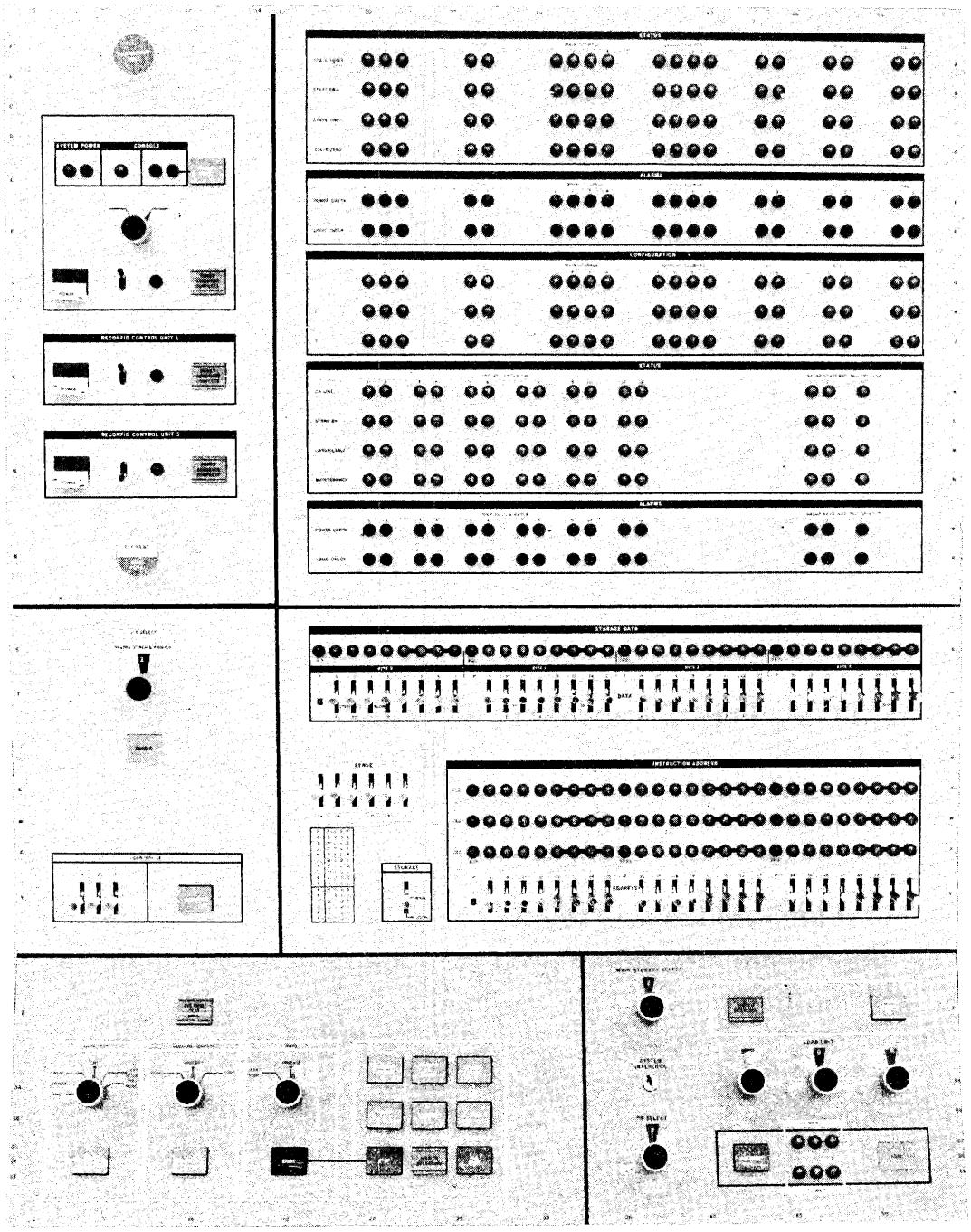


Figure 8-2. CC Operator's Panel

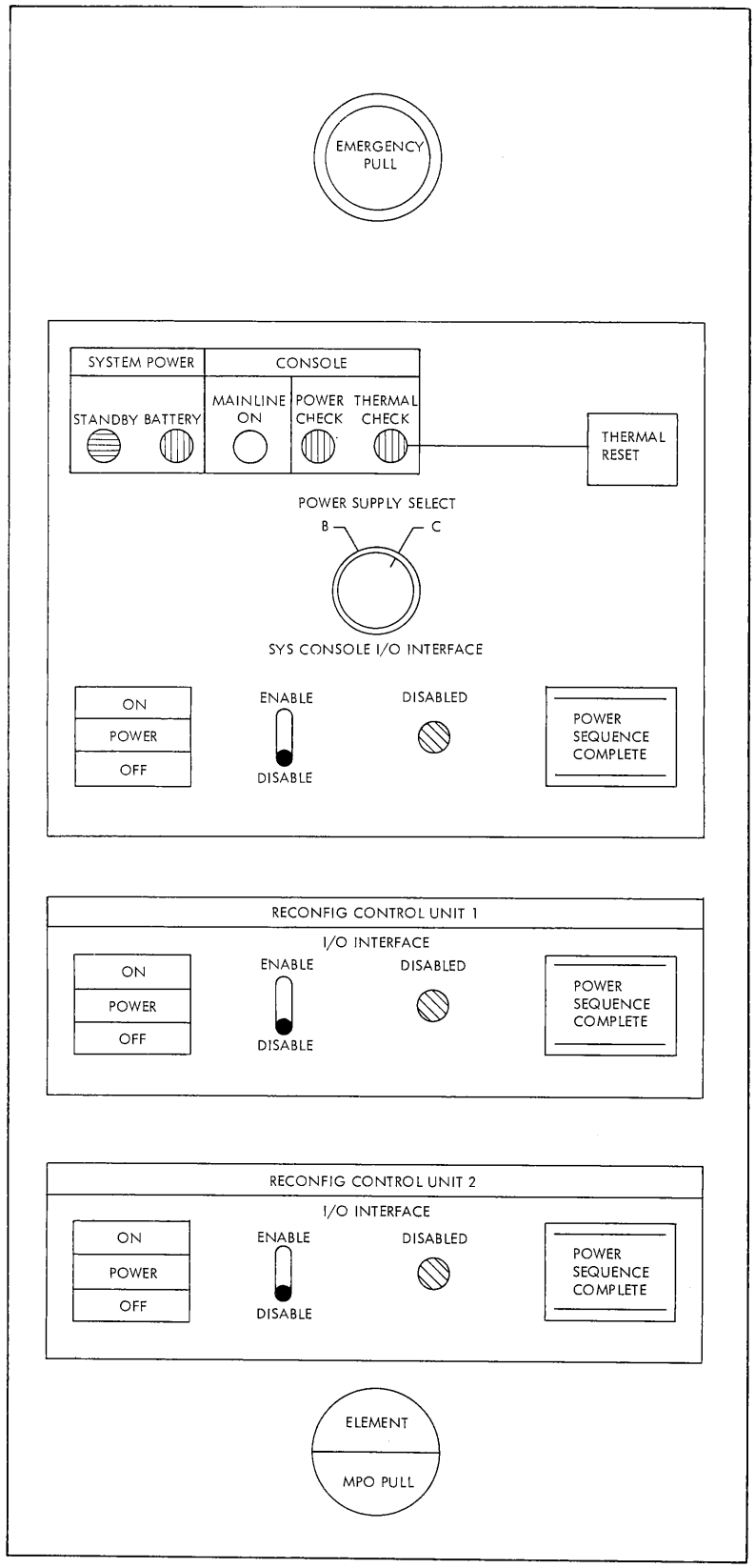


Figure 8-3. Operator's Panel, Area A

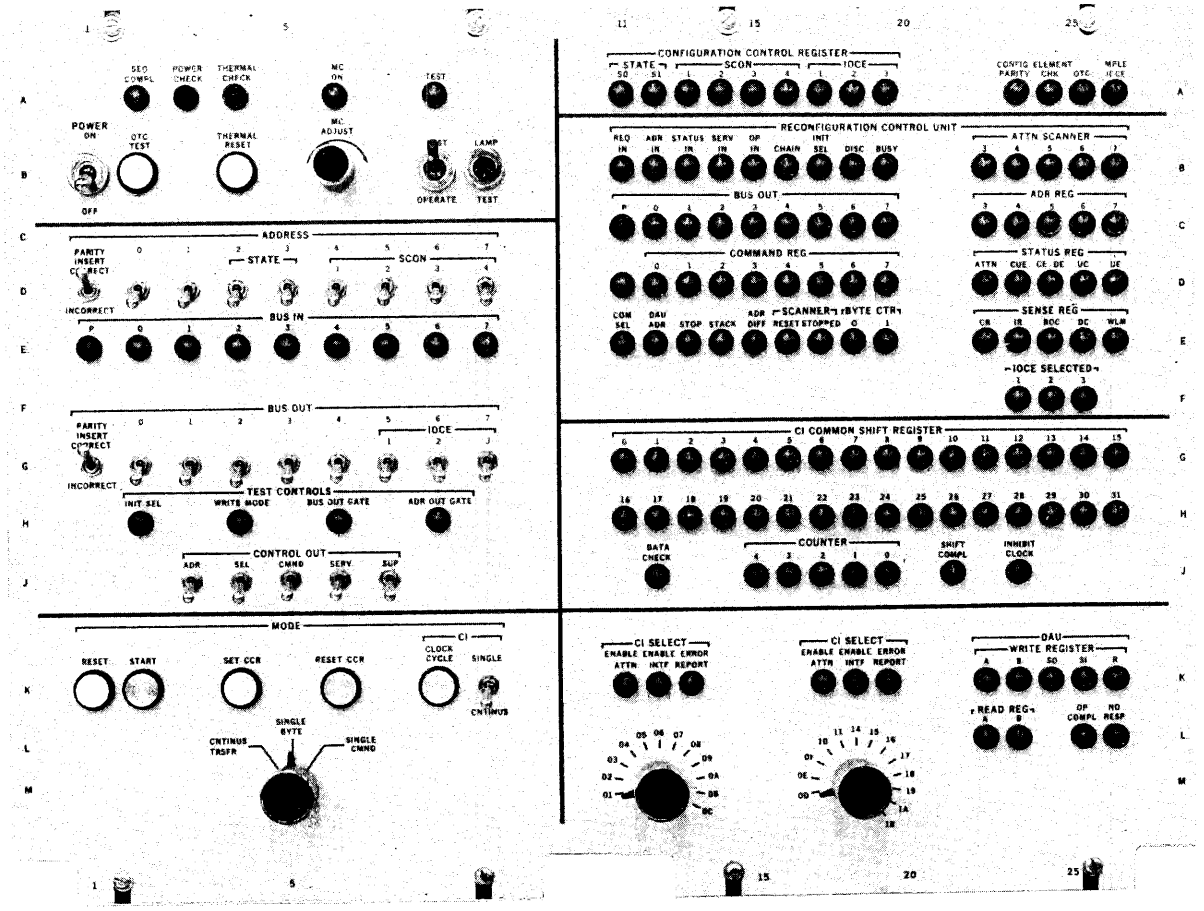


Figure 8-4. RCU Maintenance Panel (Gates A & B)

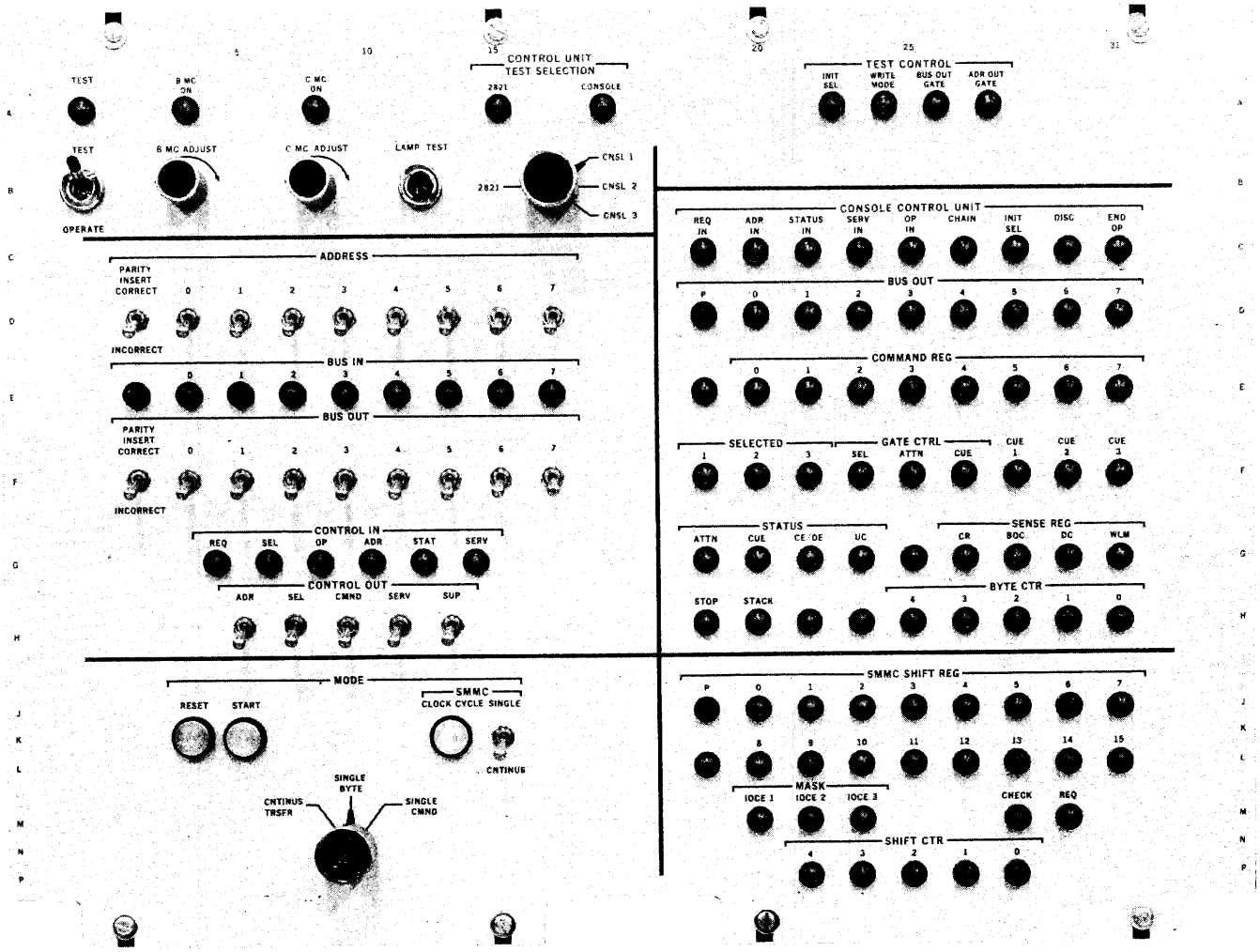


Figure 8-5. SCCU Maintenance Panel (D Gate)

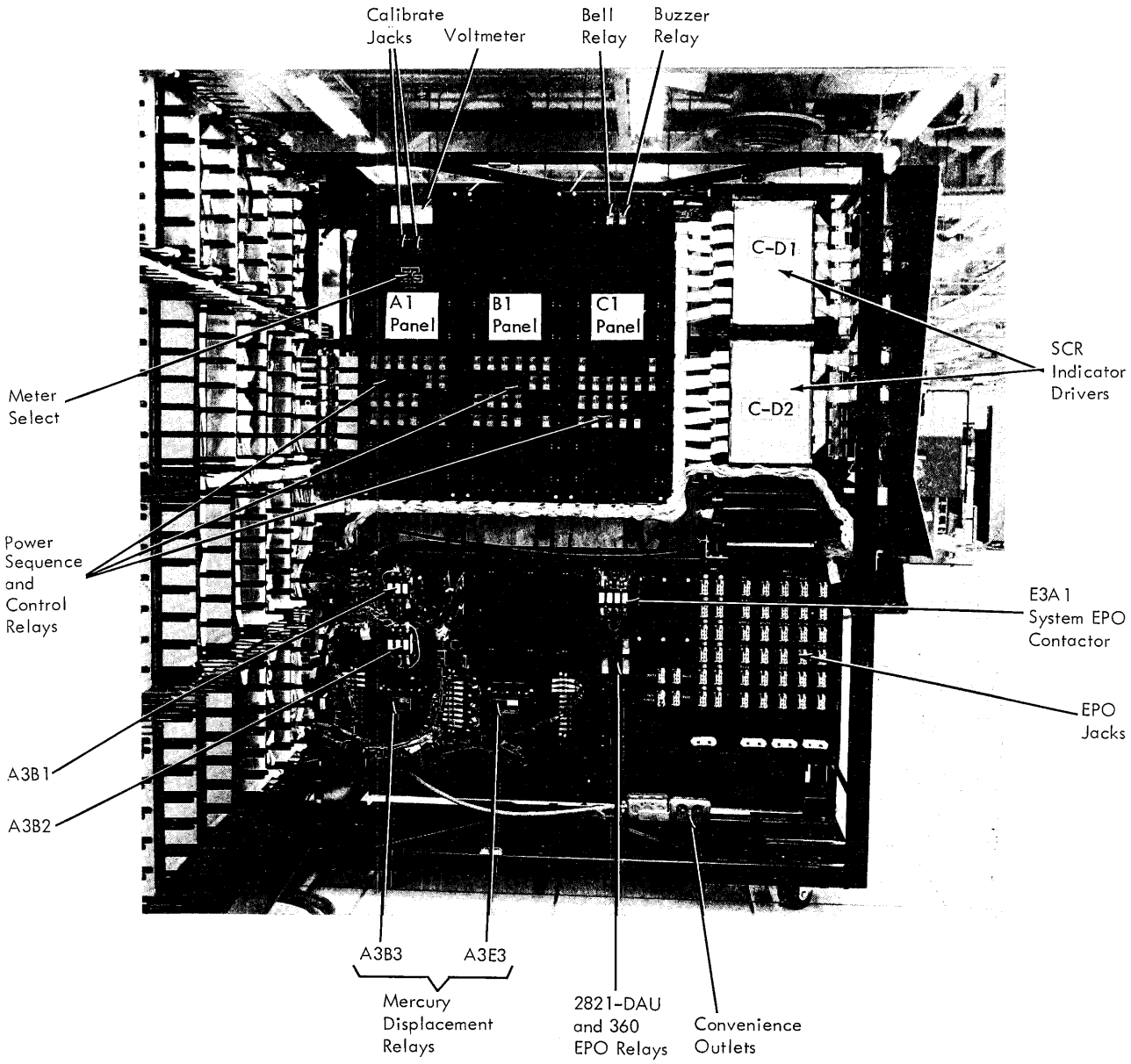


Figure 8-6. C Gate (Component Side)

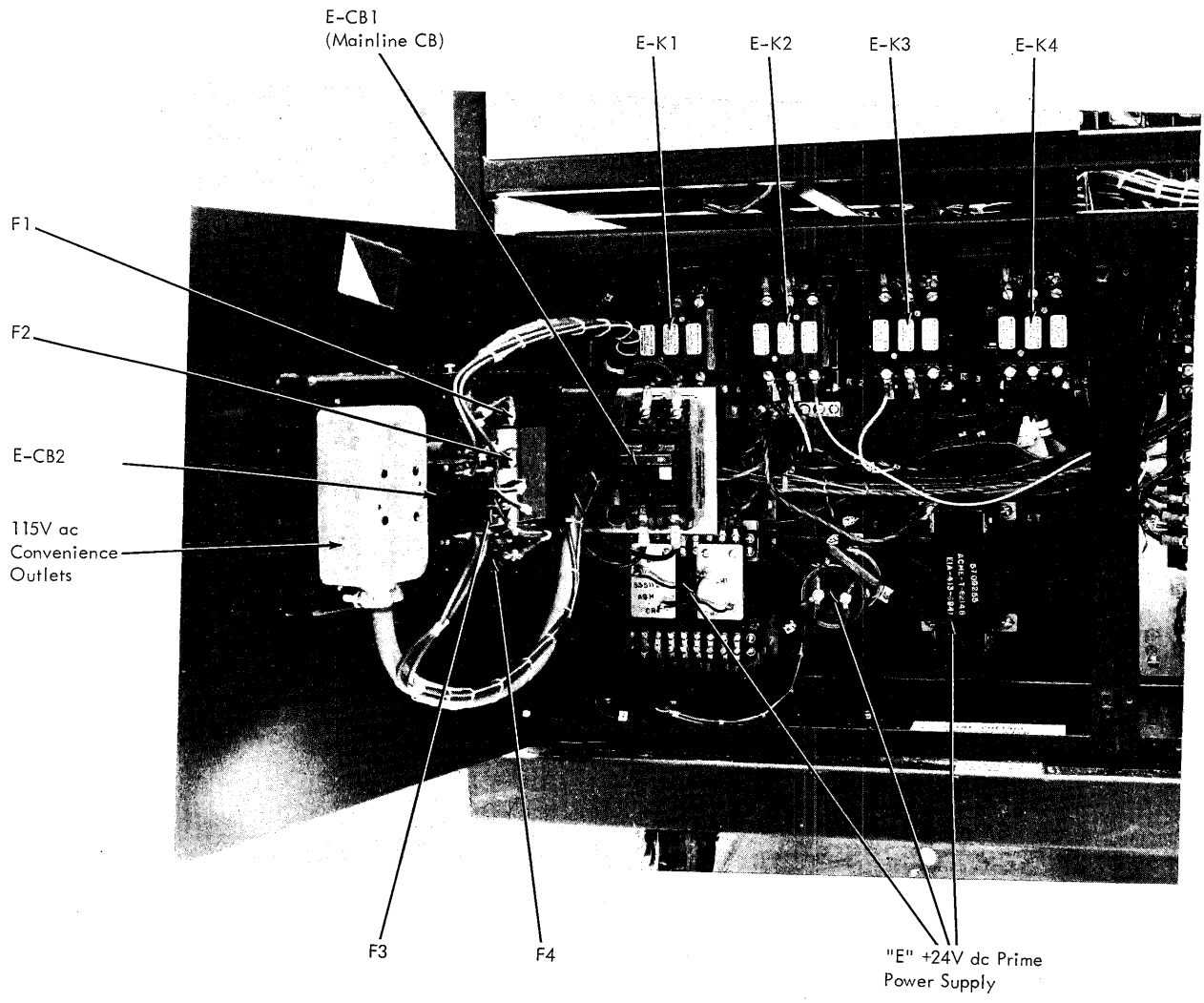


Figure 8-7. E Prime Power Box

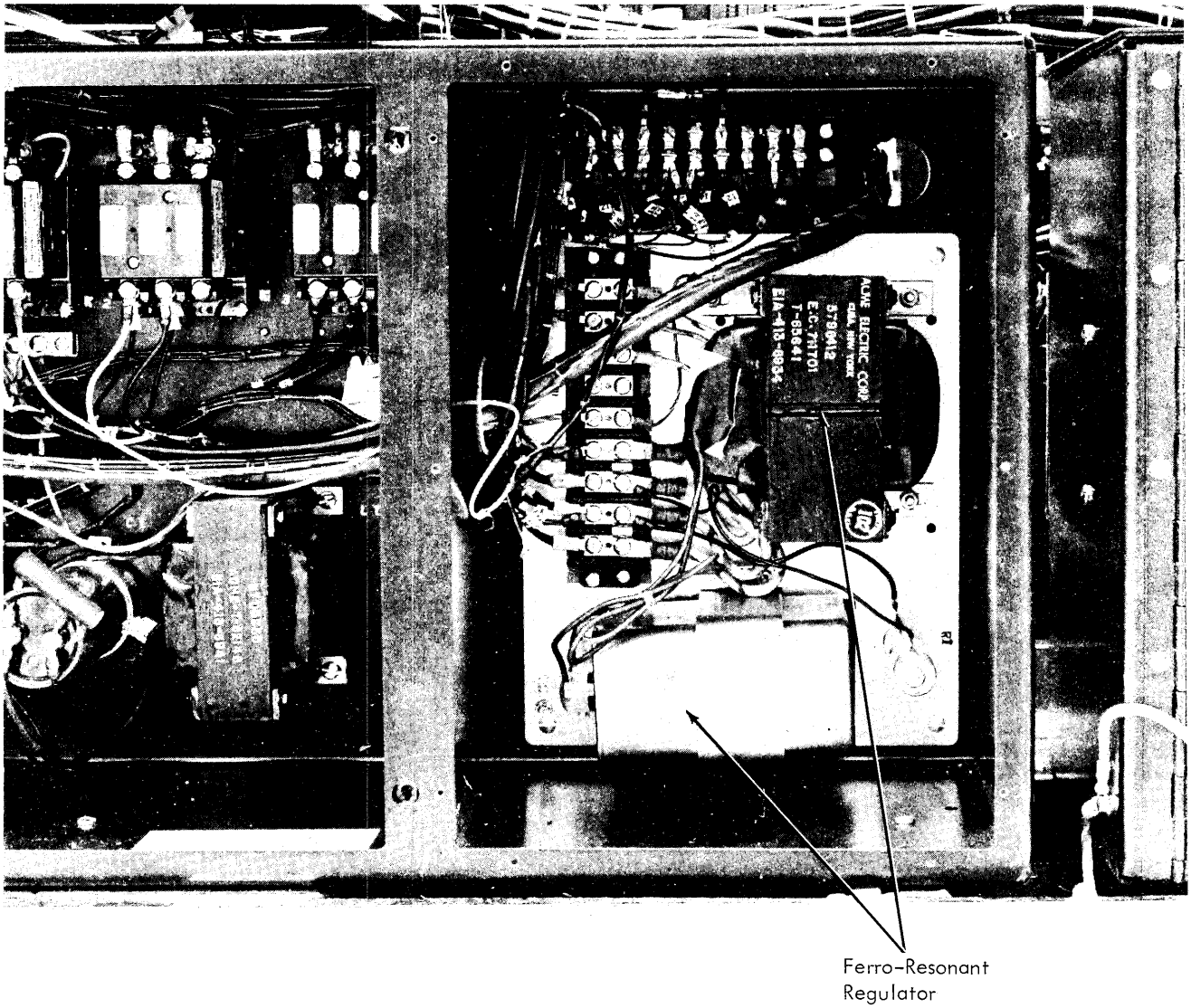


Figure 8-8. PS2 (E or F) 7.25V ac SCR Supply

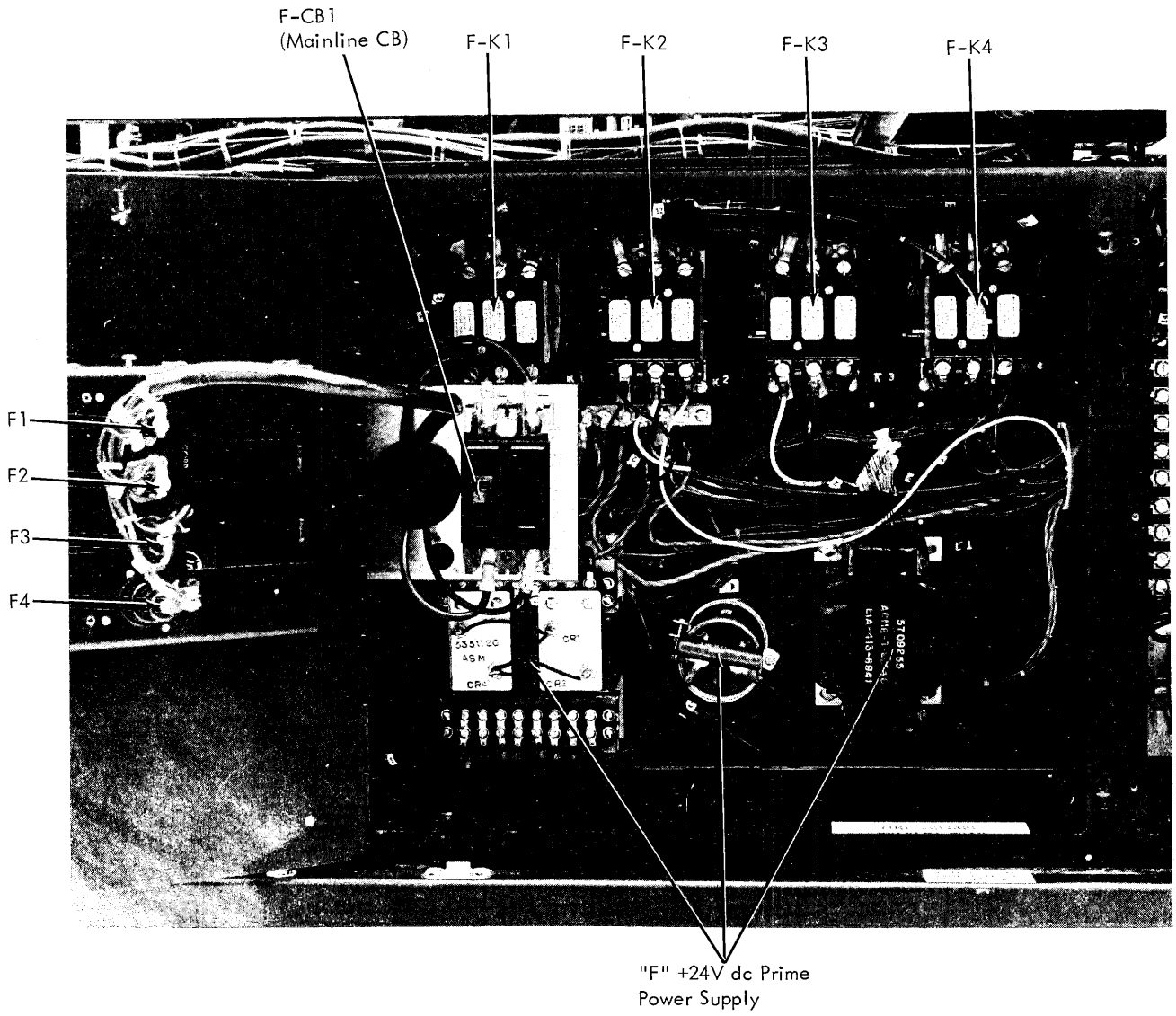


Figure 8-9. F Prime Power Box

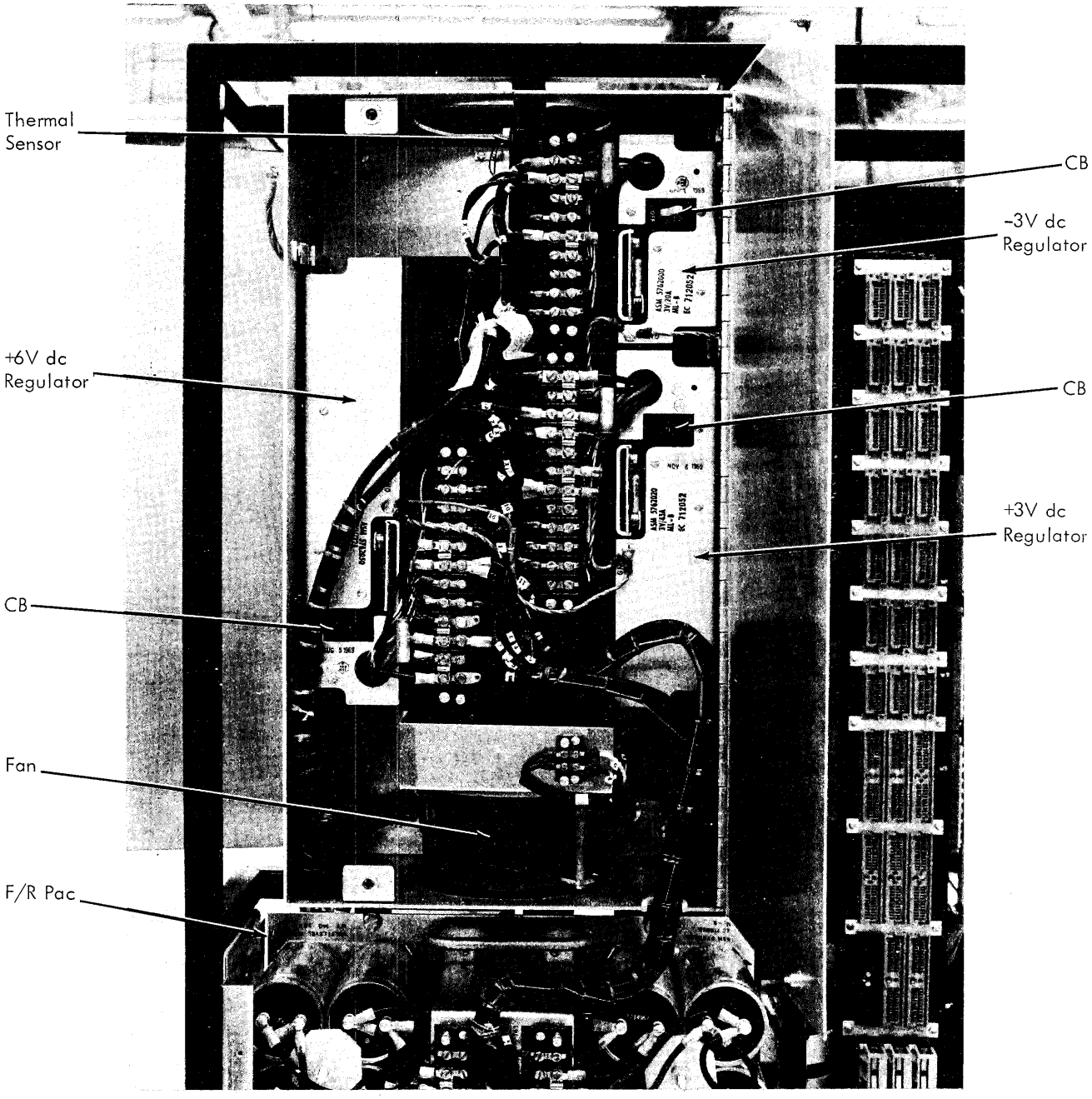


Figure 8-10. Power Tub

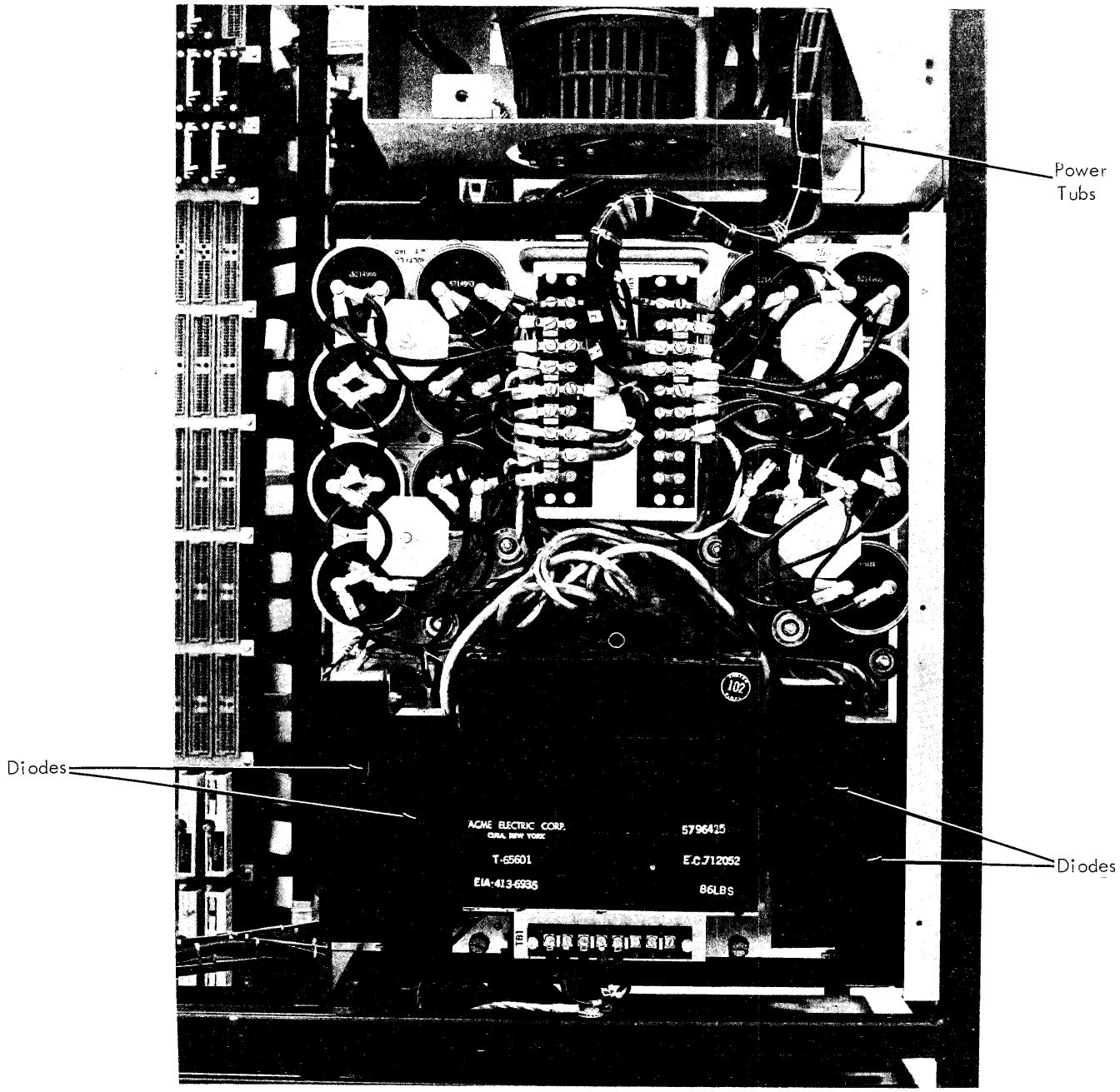


Figure 8-11. F/R PAC

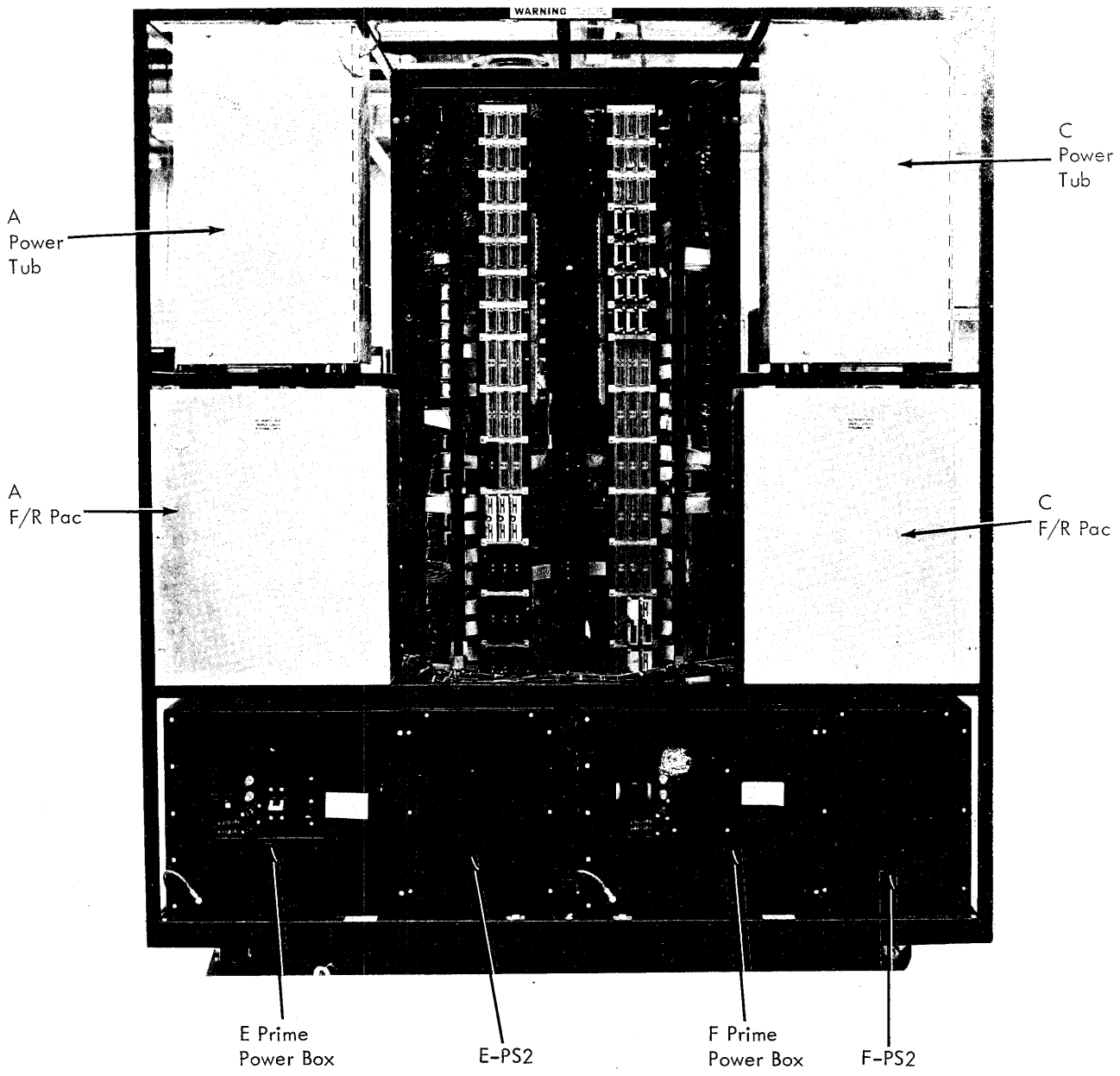


Figure 8-12. Rear View of CC

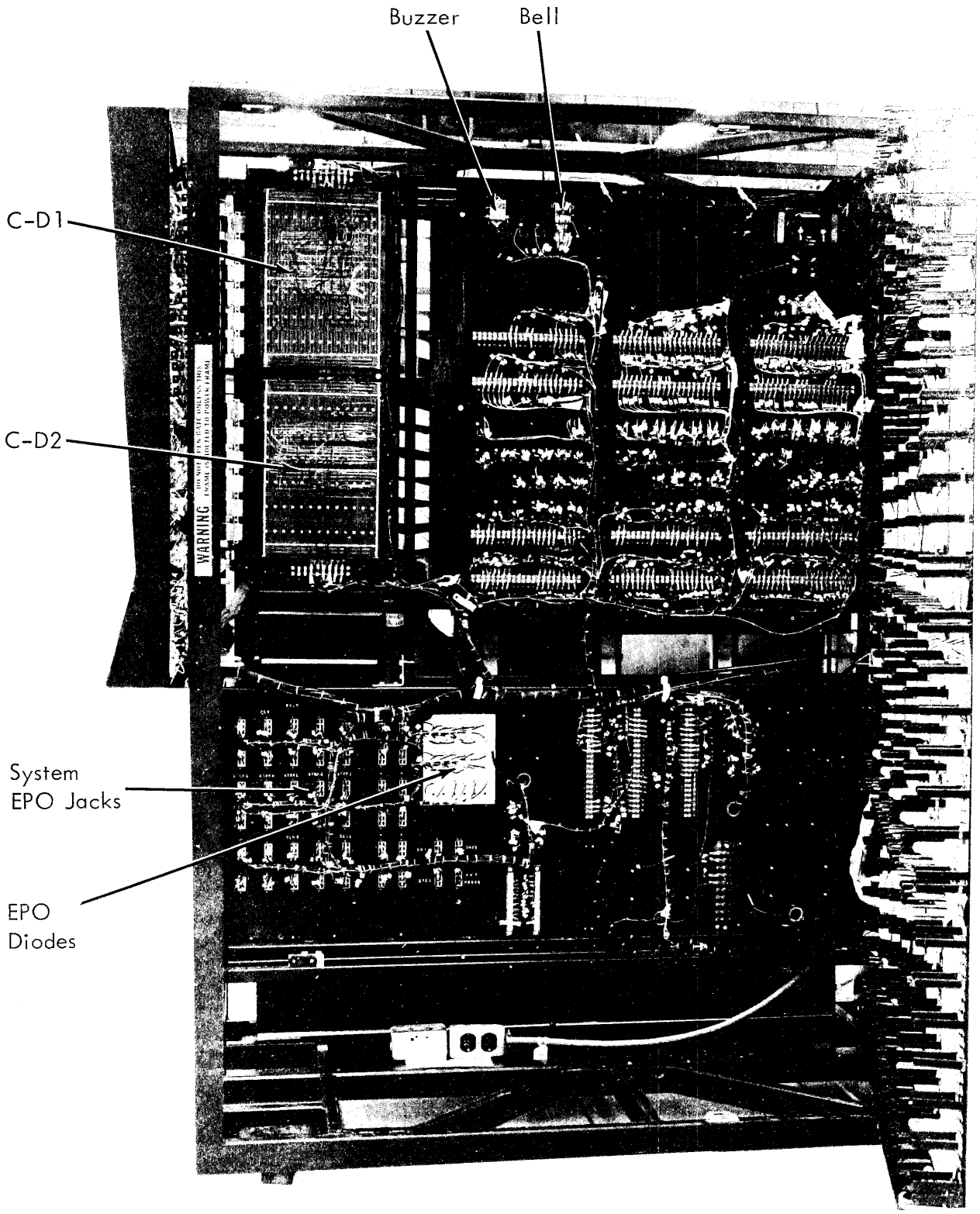


Figure 8-13. C Gate (Wiring Side)

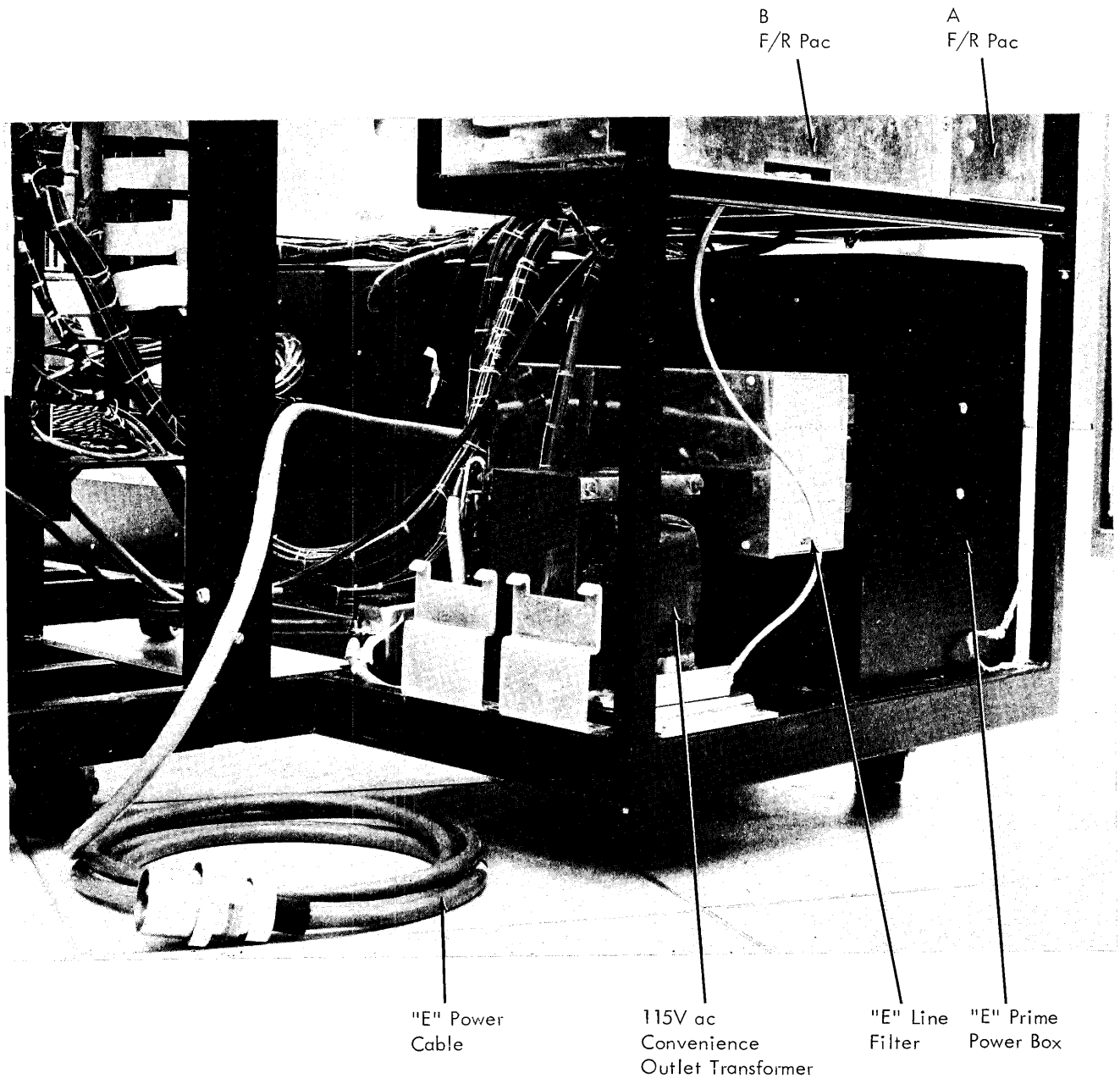


Figure 8-14. E Line Filter and 115V ac Transformer

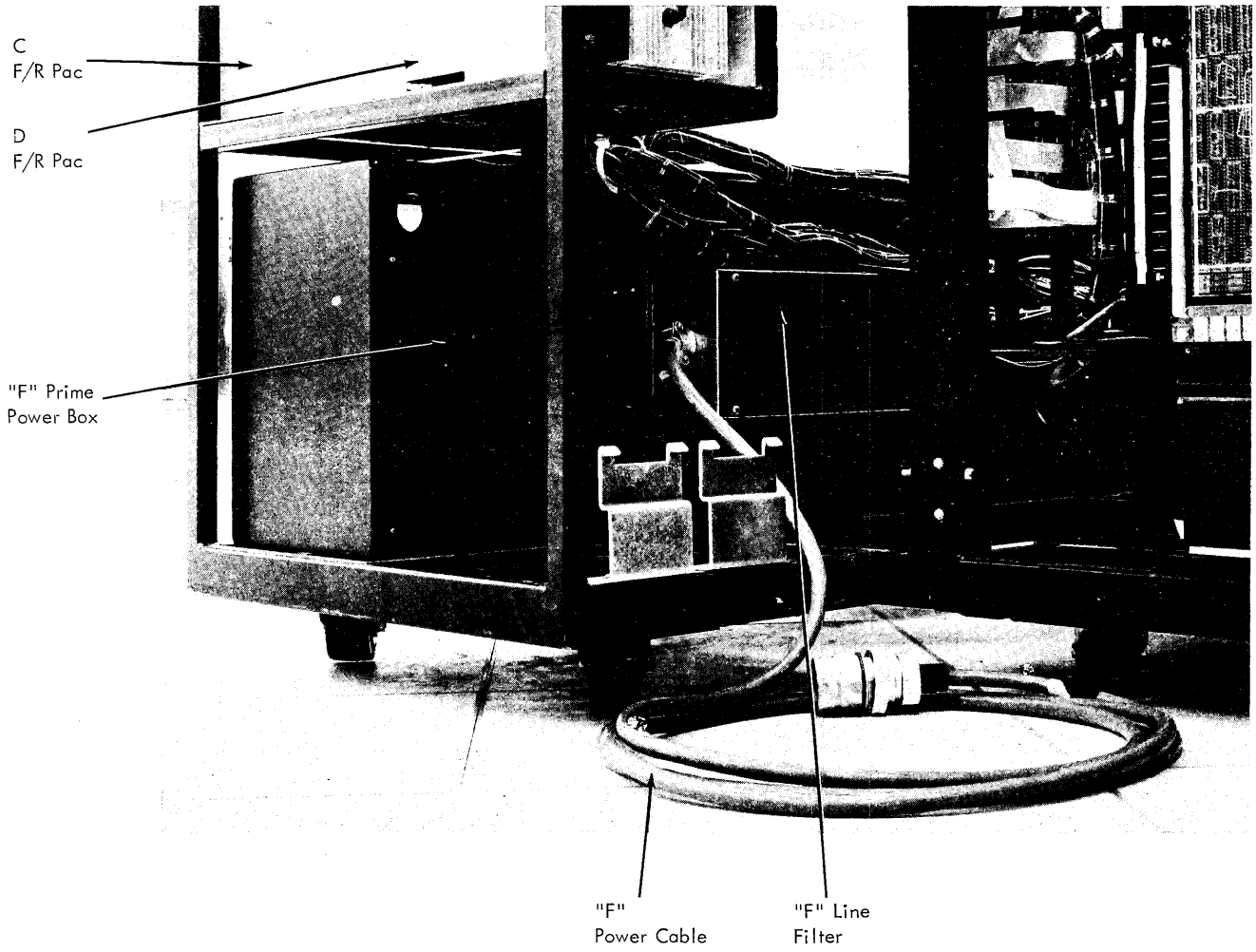
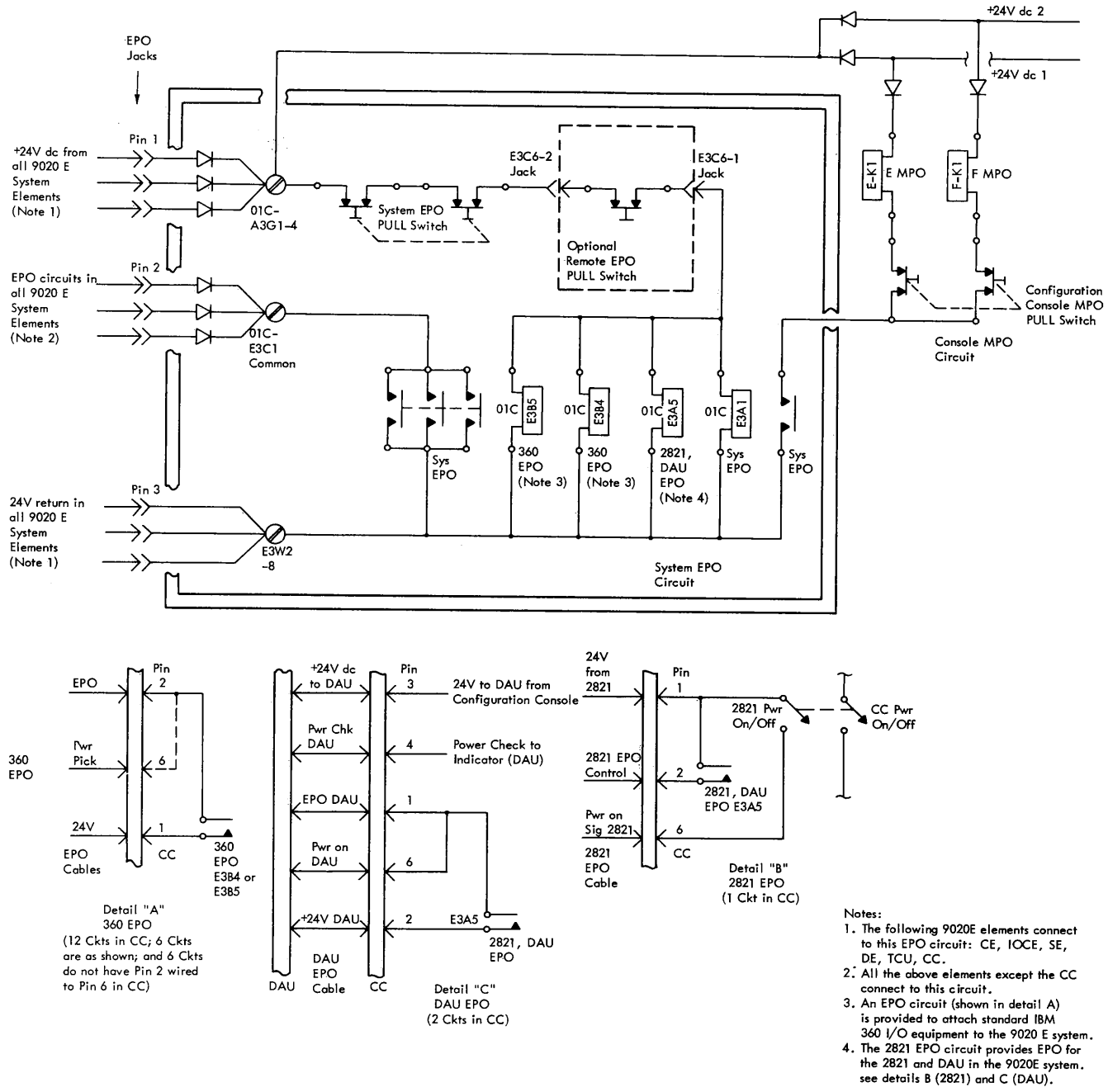


Figure 8-15. F Line Filter



●Figure 8-16. 9020E EPO

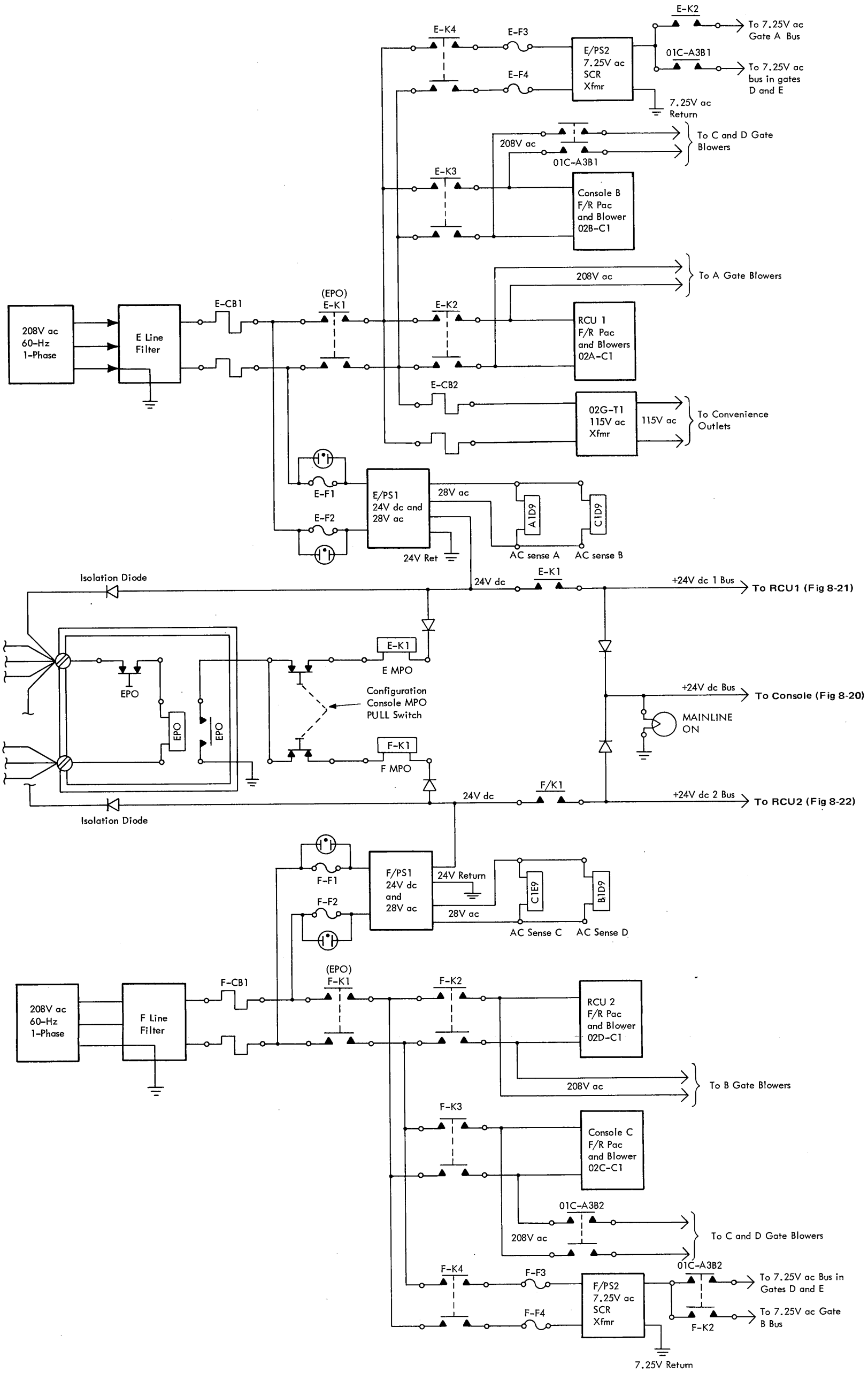


Figure 8-17. 7265-03 AC Distribution

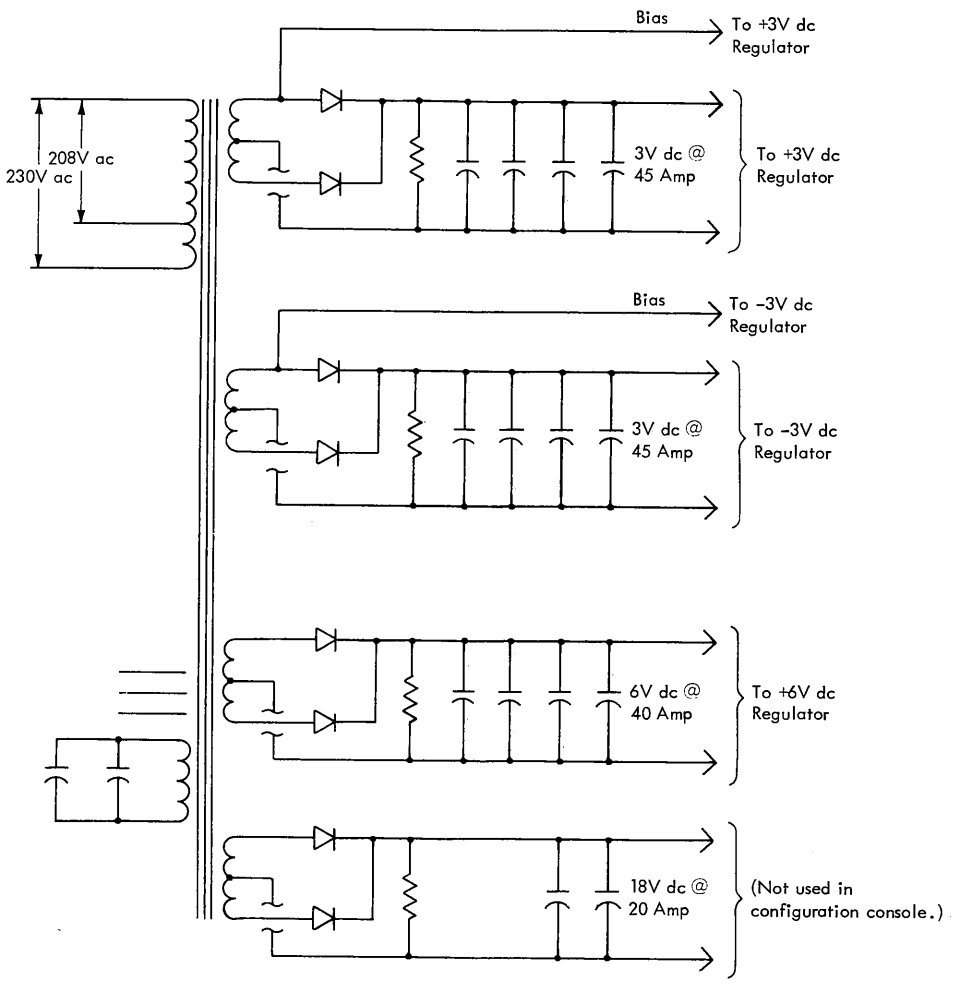
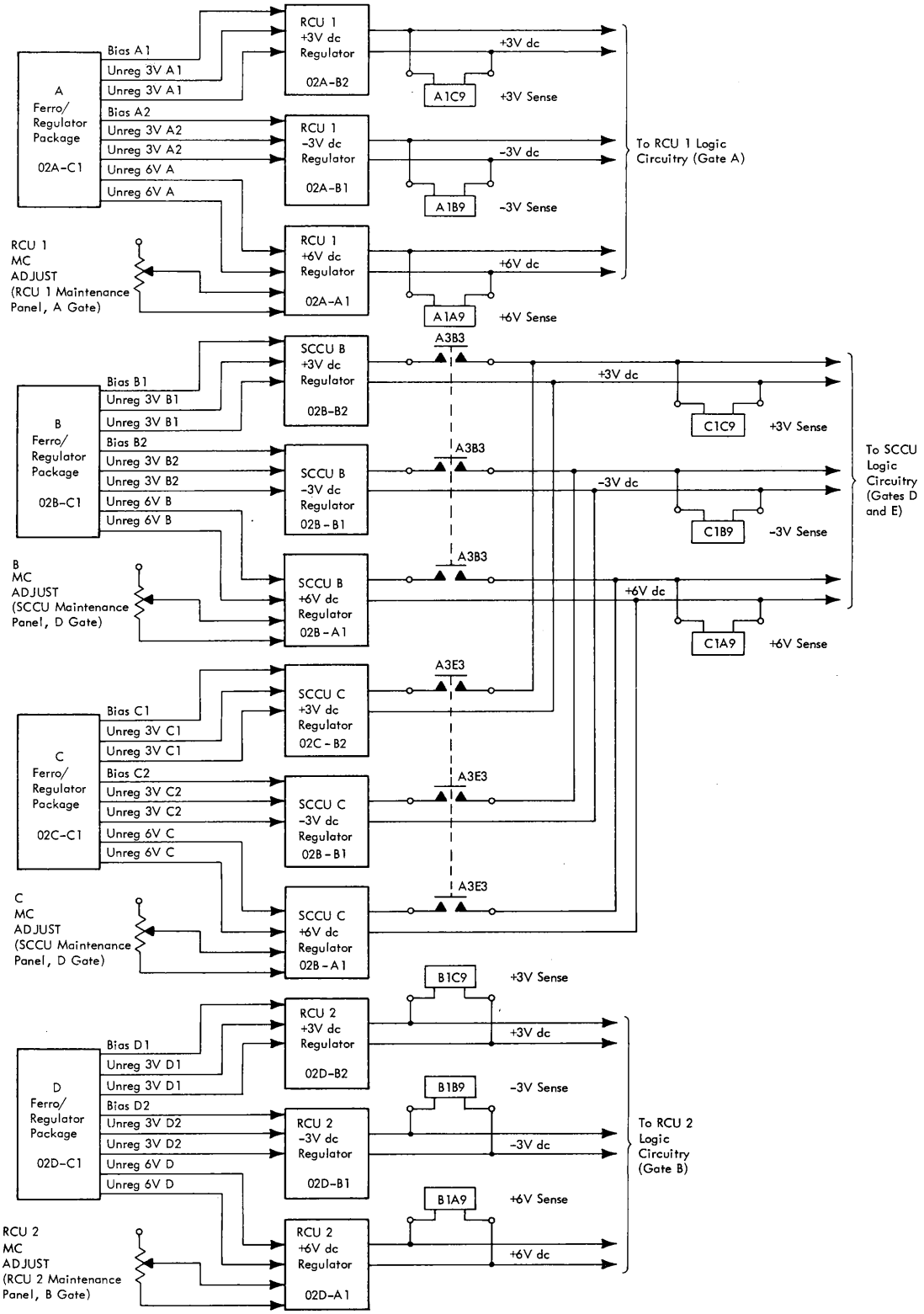
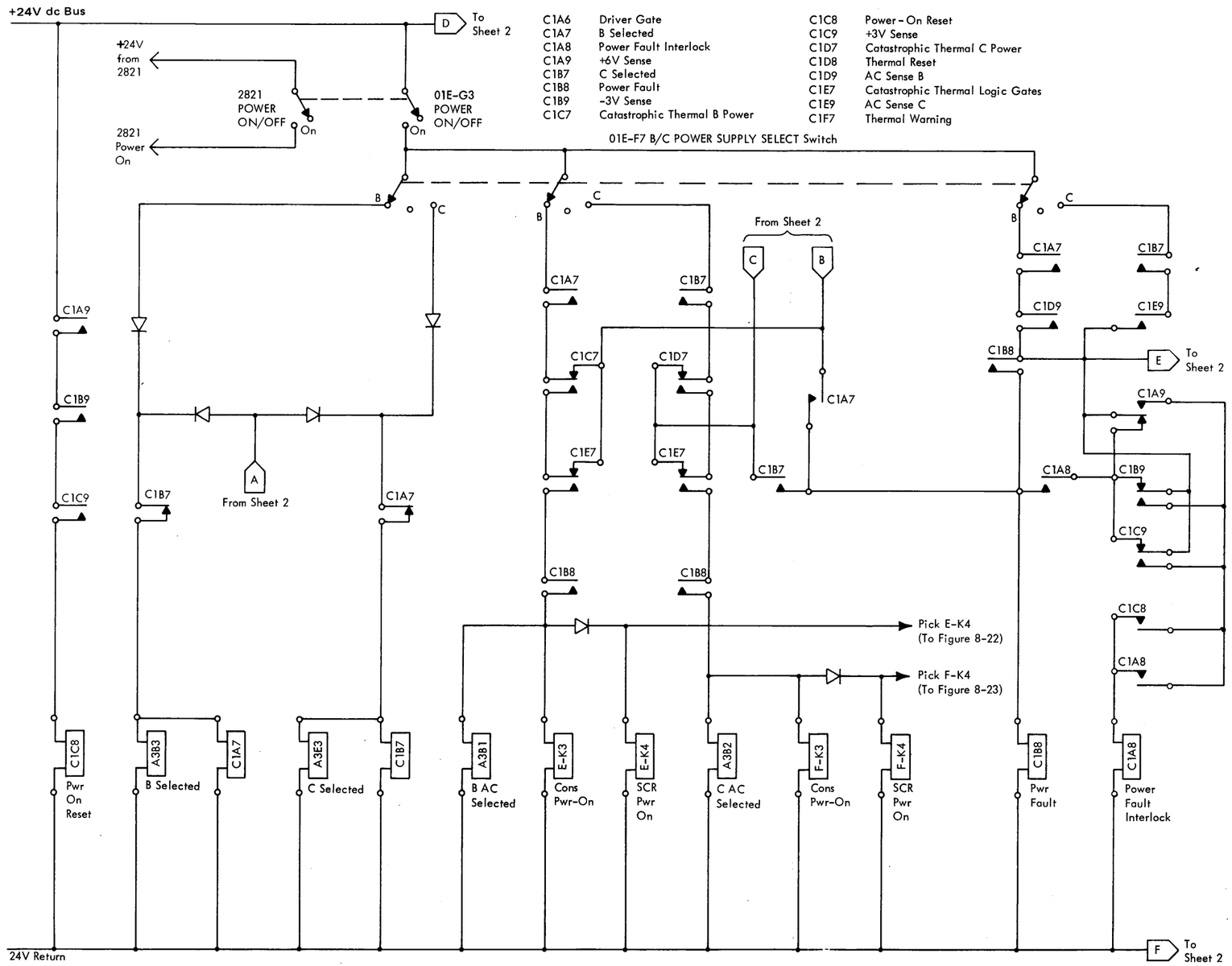


Figure 8-18. Ferro-Regulator Package (F/R PAC)



●Figure 8-19. DC Regulators

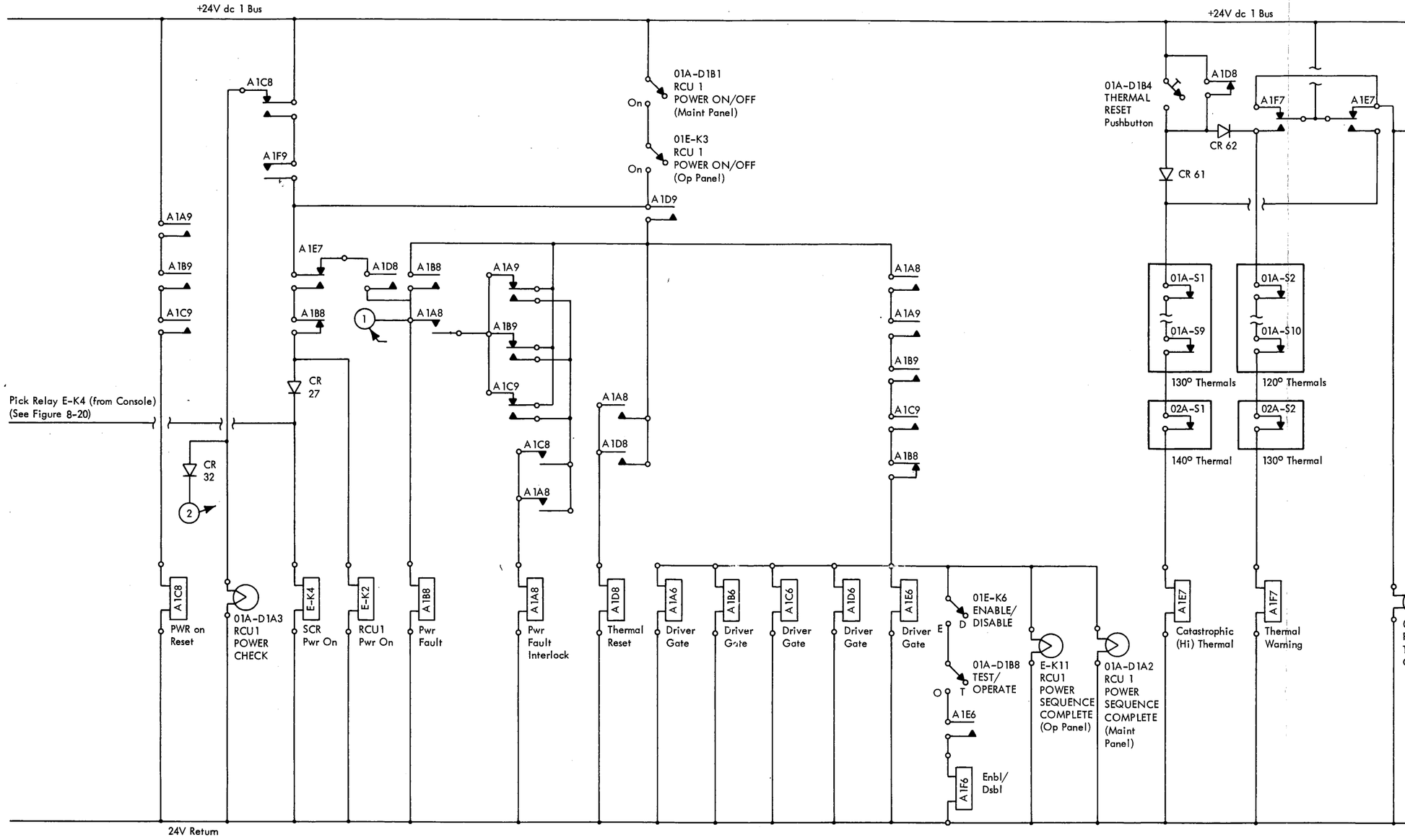


●Figure 8-20. SCCU Power Sequence and Control Circuitry (Sheet 1 of 2)

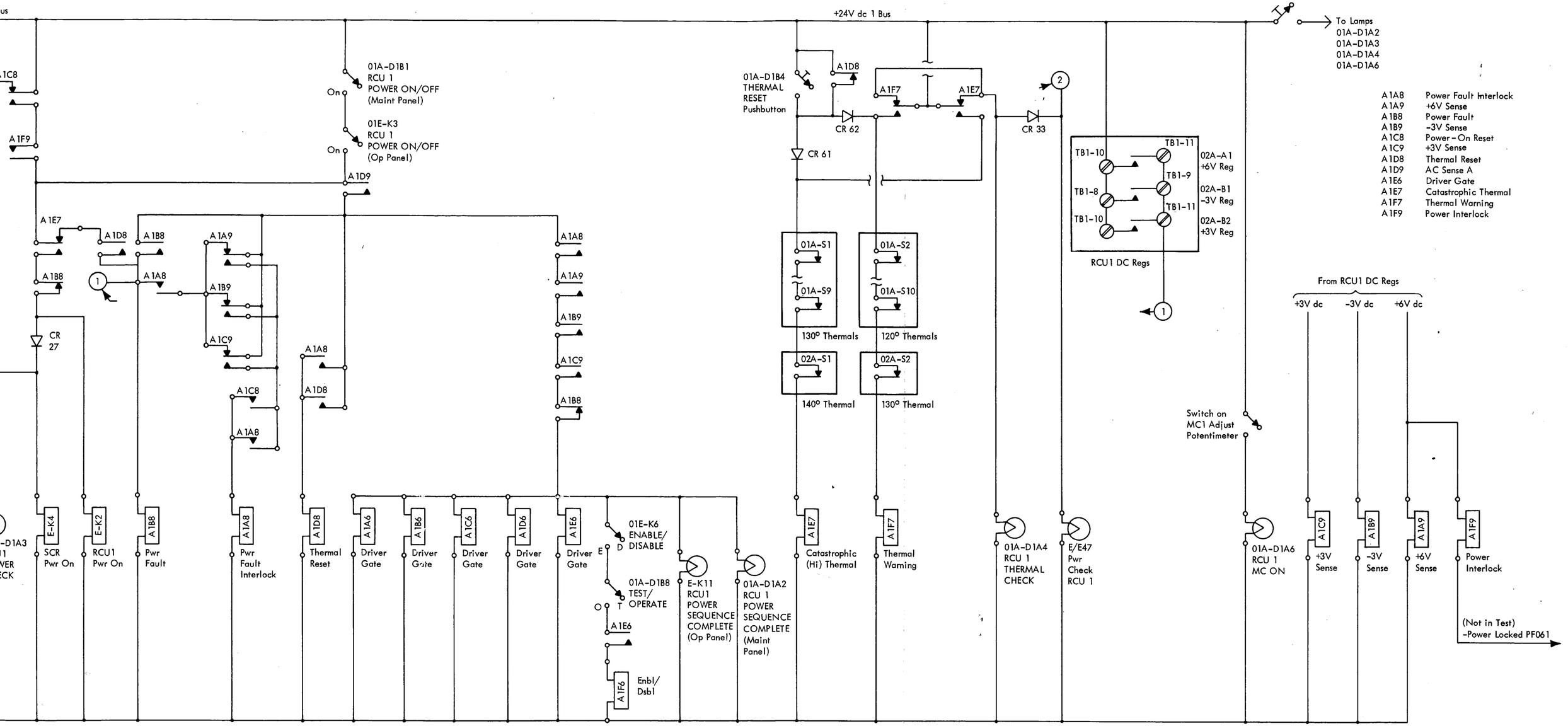
C1A6 Driver Gate
C1A7 B Selected
C1A8 Power Fault Interlock
C1A9 +6V Sense
C1B7 C Selected
C1B8 Power Fault
C1B9 -3V Sense
C1C7 Catastrophic Thermal B Power
C1C8 Power-On Reset
C1C9 +3V Sense
C1D7 Catastrophic Thermal C Power
C1D8 Thermal Reset
C1D9 AC Sense B
C1E7 Catastrophic Thermal Logic Gates
C1E9 AC Sense C
C1F7 Thermal Warning

From Sheet 1 D
From Sheet 1 E
From Sheet 1 F
To Sheet 1 A
To Sheet 1 B
To Sheet 1 C
01E-E11 Thermal Reset Pushbutton
01E-G6 ENABLE/ DISABLE
01D-A1B12 LAMP TEST
Lamp Test for 01D-A1A3 01D-A1A8
02B-A1 +6V Reg
02B-B1 -3V Reg
02B-B2 +3V Reg
02C-A1 +6V Reg
02C-B1 -3V Reg
02C-B2 +3V Reg
TB1-10
TB1-8
TB1-11
TB1-9
Cons B DC Regs
Cons C DC Regs
DC Regs for Console (In Power Tubs B and C)
+6V dc
-3V dc
+3V dc
02B
02C
A3B3
A3E3
CR 51
CR 52
CR 53
CR 54
140° Thermal
Hi Logic Thermals
Warning Thermals
B MC
C MC
Thermal Reset
Driver Gate
Enbl/ Dsbl
E-G11 Console POWER SEQUENCE COMPLETE
E-E8 Console POWER CHECK
Catastrophic (Hi) Thermal B Pwr
Catastrophic (Hi) Thermal C Pwr
Catastrophic (Hi) Thermal Logic Gates
Thermal Warning
E-E9 THERMAL CHECK
01D-A1A3 B MC ON
01D-A1A8 C MC ON
To Gate D Bus
+6V Sense
-3V Sense
+3V Sense
24V Return

●Figure 8-20. SCCU Power Sequence and Control Circuitry (Sheet 2 of 2)



●Figure 8-21. RCU 1 Power Sequence and Control Circuitrv



trol Circuitry

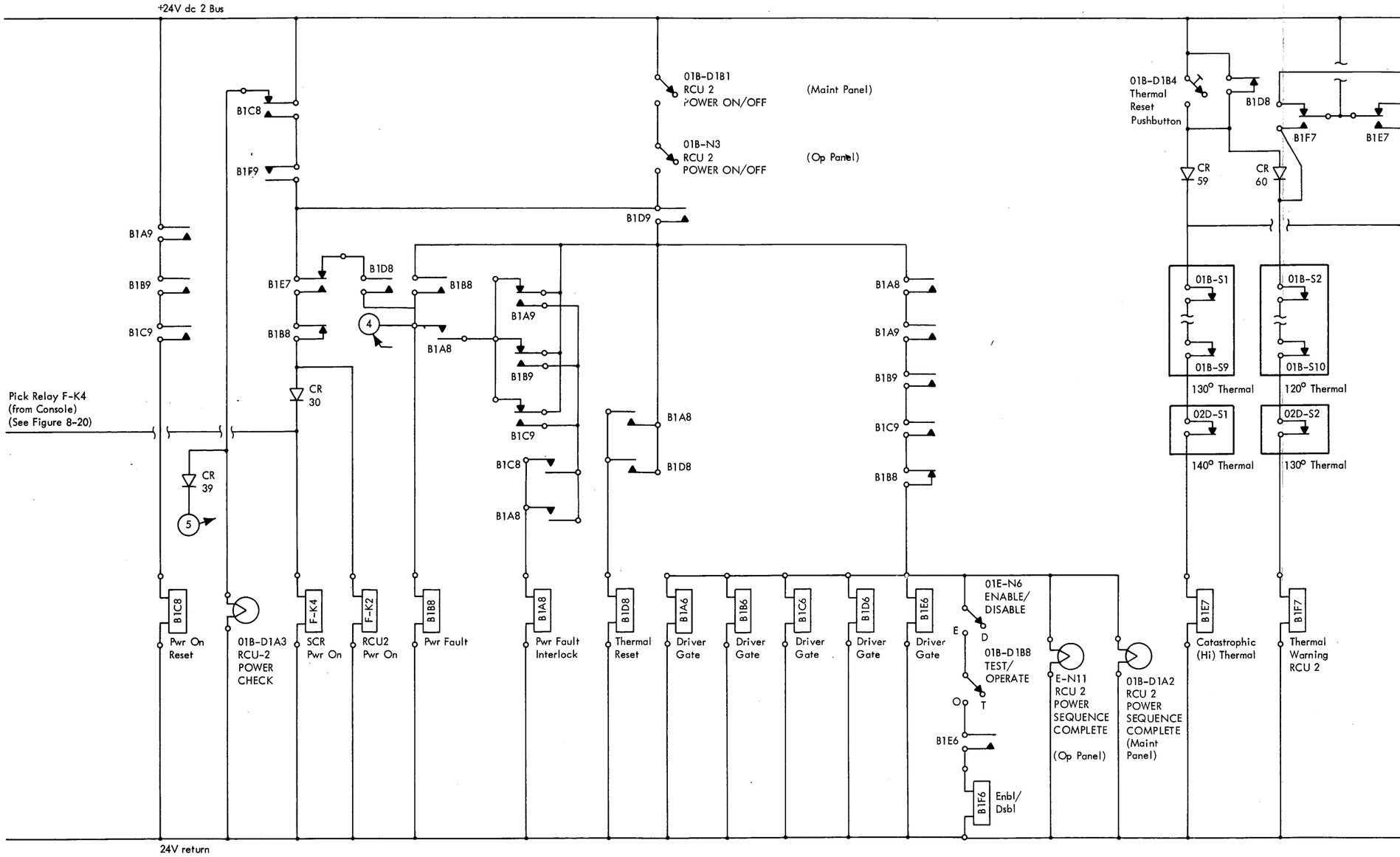
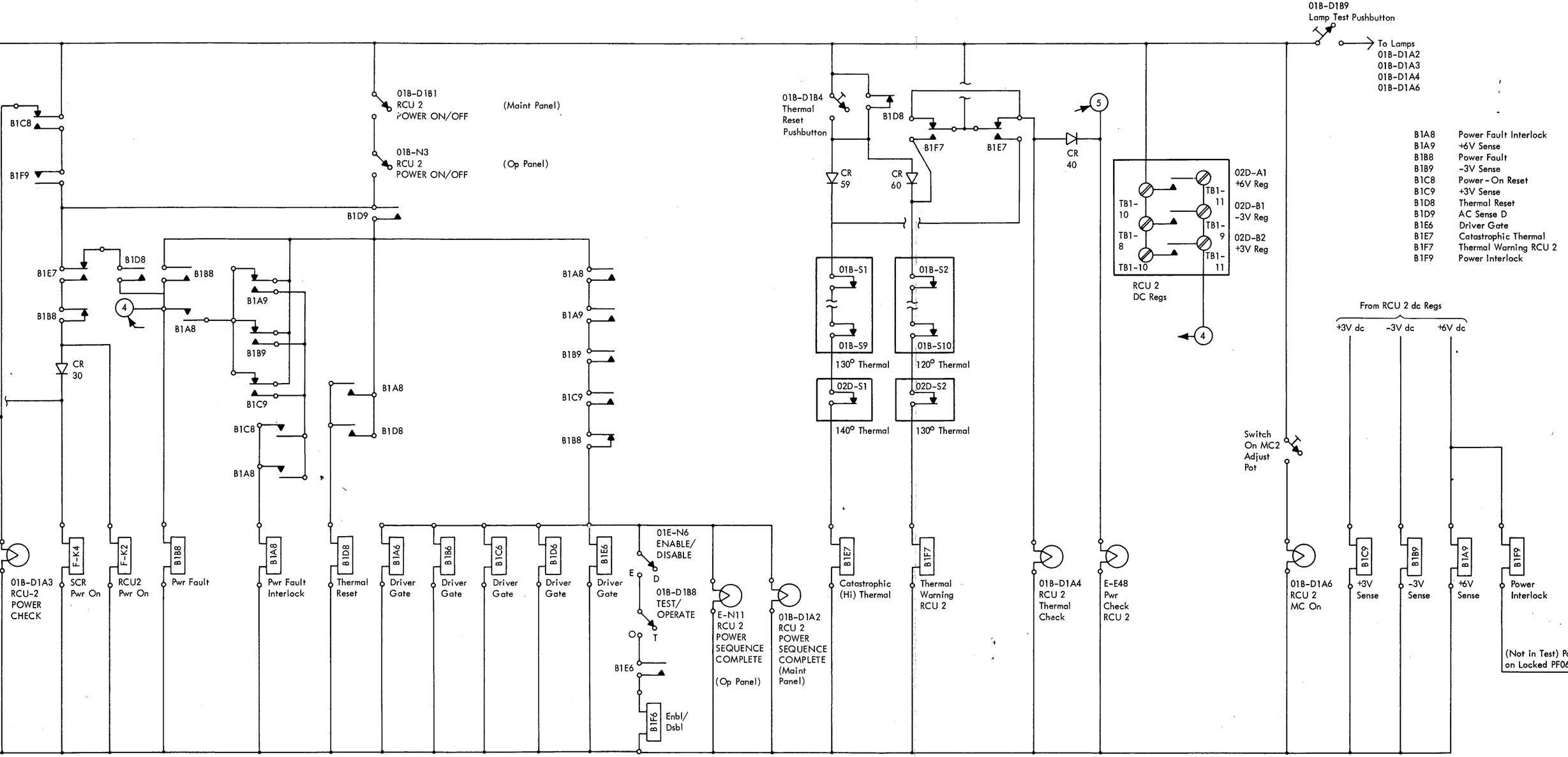


Figure 8-22. RCU 2 Power Sequence and Control Circuitry



d Control Circuitry

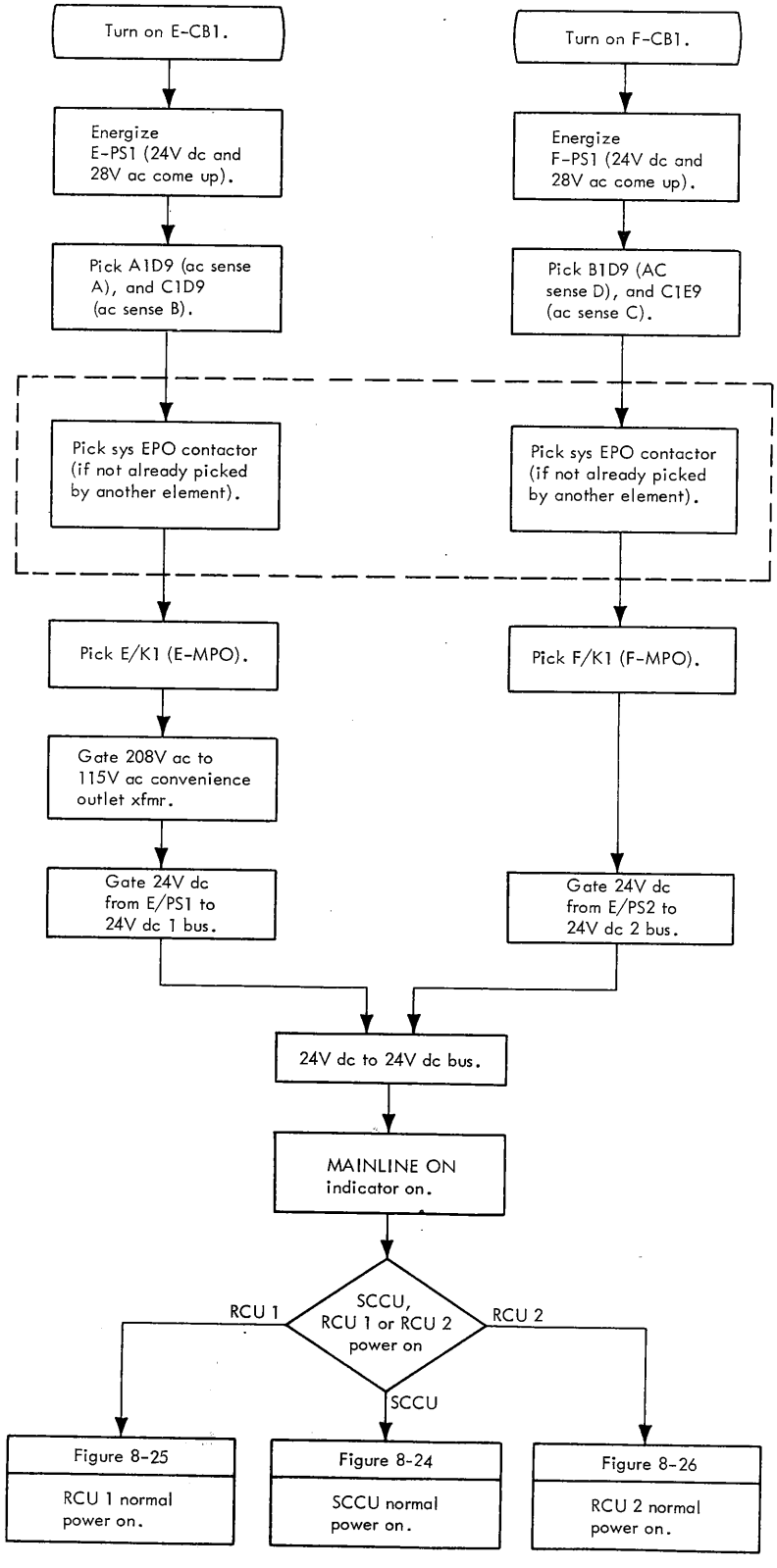

Turn on E-CB1.
Turn on F-CB1.
Energize E-PS1 (24V dc and 28V ac come up).
Energize F-PS1 (24V dc and 28V ac come up).
Pick A1D9 (ac sense A), and C1D9 (ac sense B).
Pick B1D9 (AC sense D), and C1E9 (ac sense C).
Pick sys EPO contactor (if not already picked by another element).
Pick sys EPO contactor (if not already picked by another element).
Pick E/K1 (E-MPO).
Pick F/K1 (F-MPO).
Gate 208V ac to 115V ac convenience outlet xfmr.
Gate 24V dc from E/PS1 to 24V dc 1 bus.
Gate 24V dc from E/PS2 to 24V dc 2 bus.
24V dc to 24V dc bus.
MAINLINE ON indicator on.
SCCU, RCU 1 or RCU 2 power on
RCU 1
RCU 2
SCCU
Figure 8-25
RCU 1 normal power on.
Figure 8-24
SCCU normal power on.
Figure 8-26
RCU 2 normal power on.

Figure 8-23. Initial Power-On Flowchart

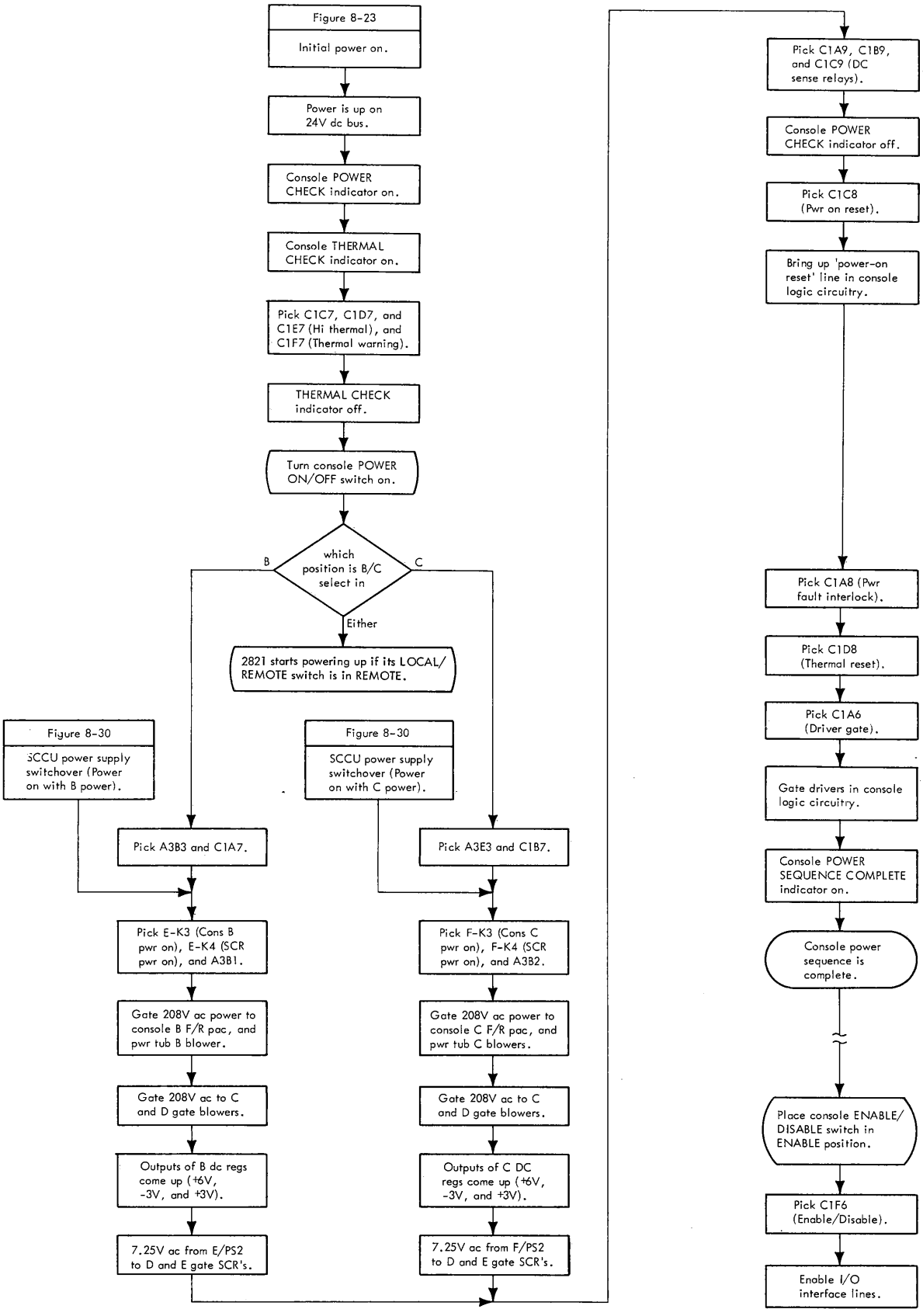


Figure 8-23
Initial power on.
Power is up on 24V dc bus.
Console POWER CHECK indicator on.
Console THERMAL CHECK indicator on.
Pick C1C7, C1D7, and C1E7 (Hi thermal), and C1F7 (Thermal warning).
THERMAL CHECK indicator off.
Turn console POWER ON/OFF switch on.
which position is B/C select in
B
C
Either
2821 starts powering up if its LOCAL/REMOTE switch is in REMOTE.
Figure 8-30
SCCU power supply switchover (Power on with B power).
Figure 8-30
SCCU power supply switchover (Power on with C power).
Pick A3B3 and C1A7.
Pick A3E3 and C1B7.
Pick E-K3 (Cons B pwr on), E-K4 (SCR pwr on), and A3B1.
Pick F-K3 (Cons C pwr on), F-K4 (SCR pwr on), and A3B2.
Gate 208V ac power to console B F/R pac, and pwr tub B blower.
Gate 208V ac power to console C F/R pac, and pwr tub C blowers.
Gate 208V ac to C and D gate blowers.
Gate 208V ac to C and D gate blowers.
Outputs of B dc regs come up (+6V, -3V, and +3V).
Outputs of C DC regs come up (+6V, -3V, and +3V).
7.25V ac from E/PS2 to D and E gate SCR's.
7.25V ac from F/PS2 to D and E gate SCR's.
Pick C1A9, C1B9, and C1C9 (DC sense relays).
Console POWER CHECK indicator off.
Pick C1C8 (Pwr on reset).
Bring up 'power-on reset' line in console logic circuitry.
Pick C1A8 (Pwr fault interlock).
Pick C1D8 (Thermal reset).
Pick C1A6 (Driver gate).
Gate drivers in console logic circuitry.
Console POWER SEQUENCE COMPLETE indicator on.
Console power sequence is complete.
Place console ENABLE/DISABLE switch in ENABLE position.
Pick C1F6 (Enable/Disable).
Enable I/O interface lines.

Figure 8-24. SCCU Normal Power-On Flowchart

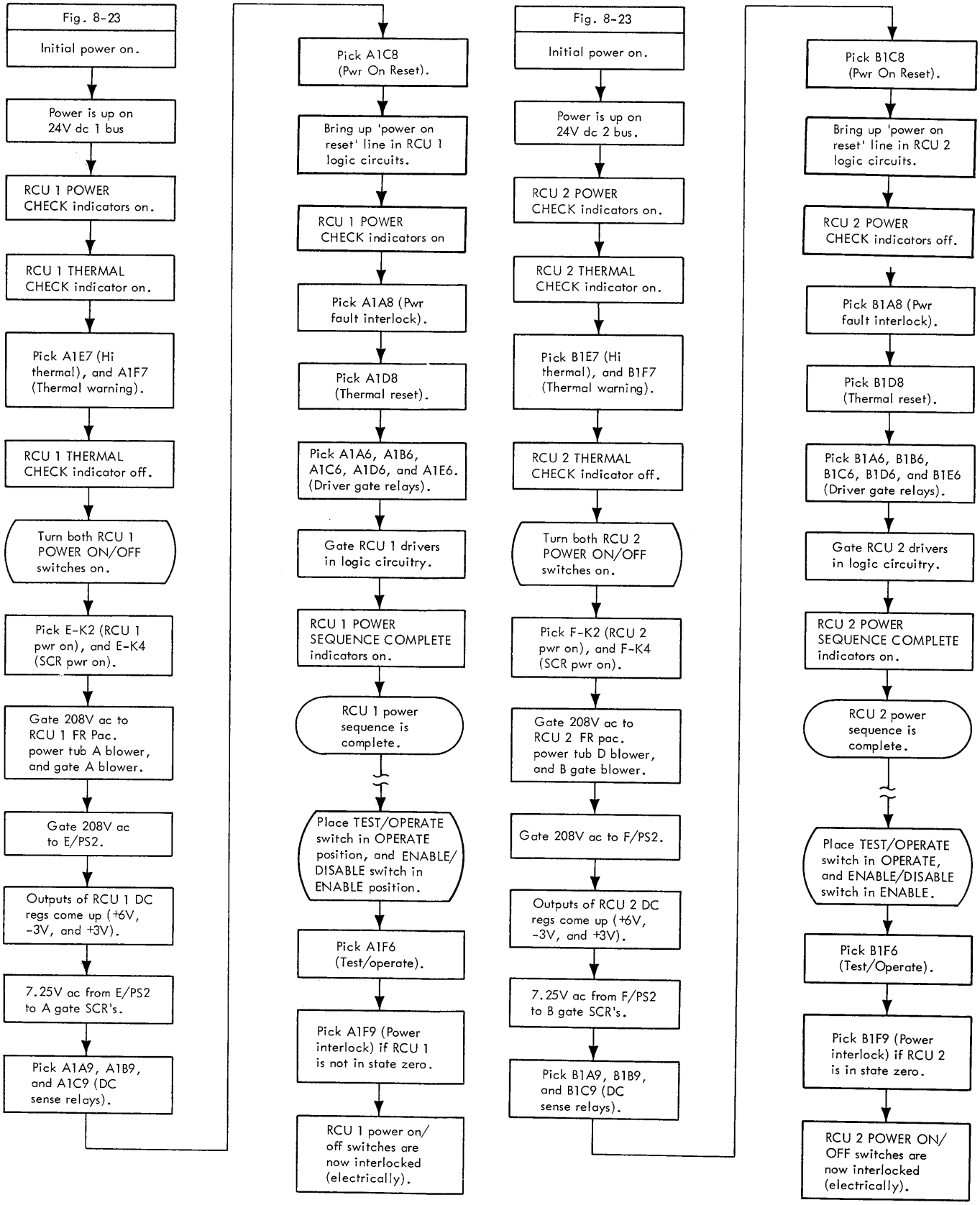


Fig. 8-23
Initial power on.
Power is up on 24V dc 1 bus
RCU 1 POWER CHECK indicators on.
RCU 1 THERMAL CHECK indicator on.
Pick A1E7 (Hi thermal), and A1F7 (Thermal warning).
RCU 1 THERMAL CHECK indicator off.
Turn both RCU 1 POWER ON/OFF switches on.
Pick E-K2 (RCU 1 pwr on), and E-K4 (SCR pwr on).
Gate 208V ac to RCU 1 FR Pac. power tub A blower, and gate A blower.
Gate 208V ac to E/PS2.
Outputs of RCU 1 DC regs come up (+6V, -3V, and +3V).
7.25V ac from E/PS2 to A gate SCR's.
Pick A1A9, A1B9, and A1C9 (DC sense relays).
Pick A1C8 (Pwr On Reset).
Bring up 'power on reset' line in RCU 1 logic circuits.
RCU 1 POWER CHECK indicators on
Pick A1A8 (Pwr fault interlock).
Pick A1D8 (Thermal reset).
Pick A1A6, A1B6, A1C6, A1D6, and A1E6. (Driver gate relays).
Gate RCU 1 drivers in logic circuitry.
RCU 1 POWER SEQUENCE COMPLETE indicators on.
RCU 1 power sequence is complete.
Place TEST/OPERATE switch in OPERATE position, and ENABLE/DISABLE switch in ENABLE position.
Pick A1F6 (Test/operate).
Pick A1F9 (Power interlock) if RCU 1 is not in state zero.
RCU 1 power on/off switches are now interlocked (electrically).
Fig. 8-23
Initial power on.
Power is up on 24V dc 2 bus.
RCU 2 POWER CHECK indicators on.
RCU 2 THERMAL CHECK indicator on.
Pick B1E7 (Hi thermal), and B1F7 (Thermal warning).
RCU 2 THERMAL CHECK indicator off.
Turn both RCU 2 POWER ON/OFF switches on.
Pick F-K2 (RCU 2 pwr on), and F-K4 (SCR pwr on).
Gate 208V ac to RCU 2 FR pac. power tub D blower, and B gate blower.
Gate 208V ac to F/PS2.
Outputs of RCU 2 DC regs come up (+6V, -3V, and +3V).
7.25V ac from F/PS2 to B gate SCR's.
Pick B1A9, B1B9, and B1C9 (DC sense relays).
Pick B1C8 (Pwr On Reset).
Bring up 'power on reset' line in RCU 2 logic circuits.
RCU 2 POWER CHECK indicators off.
Pick B1A8 (Pwr fault interlock).
Pick B1D8 (Thermal reset).
Pick B1A6, B1B6, B1C6, B1D6, and B1E6 (Driver gate relays).
Gate RCU 2 drivers in logic circuitry.
RCU 2 POWER SEQUENCE COMPLETE indicators on.
RCU 2 power sequence is complete.
Place TEST/OPERATE switch in OPERATE, and ENABLE/DISABLE switch in ENABLE.
Pick B1F6 (Test/Operate).
Pick B1F9 (Power interlock) if RCU 2 is in state zero.
RCU 2 POWER ON/OFF switches are now interlocked (electrically).

Figure 8-25. RCU 1 Normal Power-On Sequence Flowchart

Figure 8-26. RCU 2 Normal Power-On Sequence Flowchart

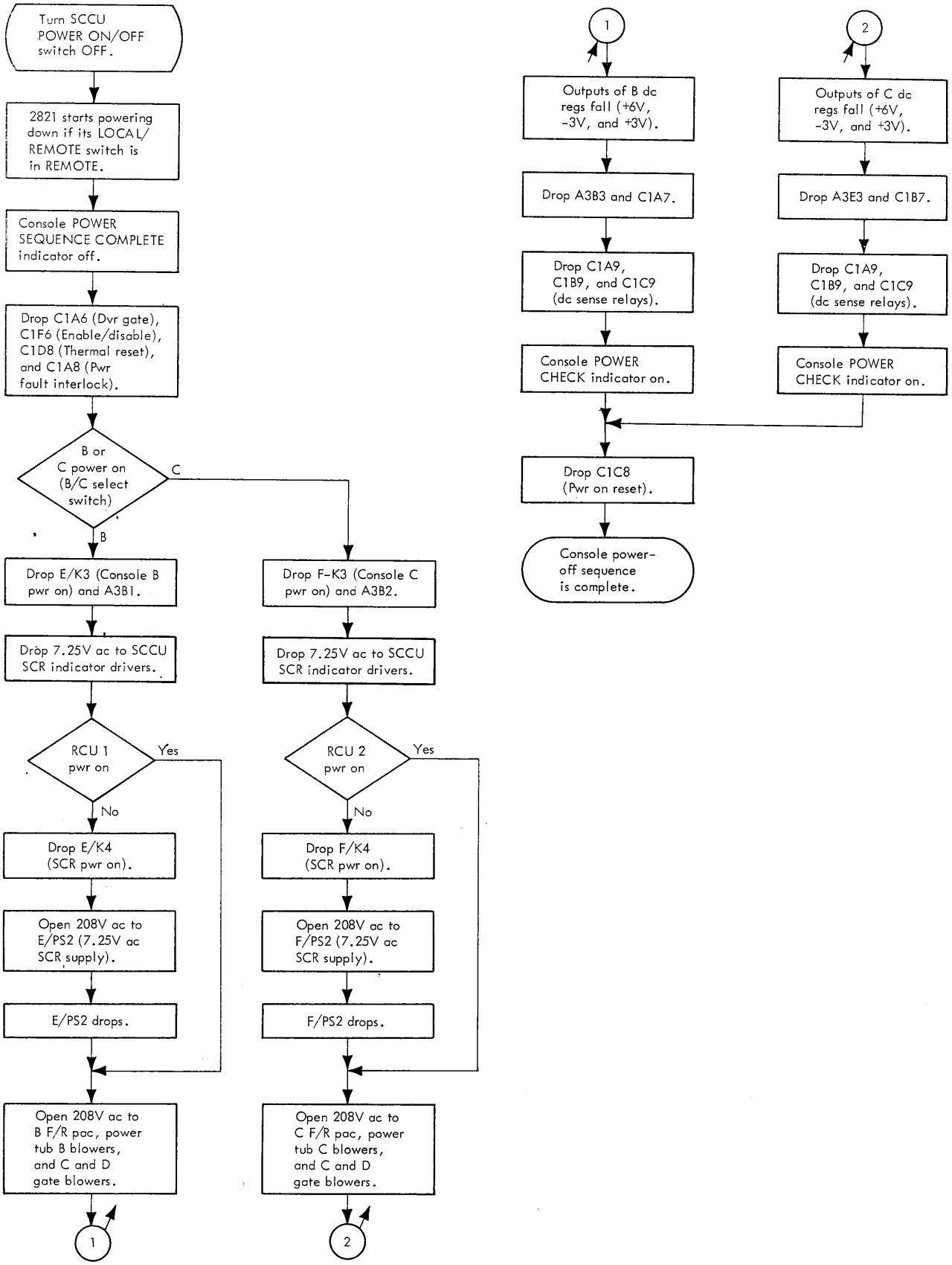

Turn SCCU POWER ON/OFF switch OFF.
2821 starts powering down if its LOCAL/REMOTE switch is in REMOTE.
Console POWER SEQUENCE COMPLETE indicator off.
Drop C1A6 (Dvr gate), C1F6 (Enable/disable), C1D8 (Thermal reset), and C1A8 (Pwr fault interlock).
B or C power on (B/C select switch)
B
C
Drop E/K3 (Console B pwr on) and A3B1.
Drop 7.25V ac to SCCU SCR indicator drivers.
RCU 1 pwr on
Yes
No
Drop E/K4 (SCR pwr on).
Open 208V ac to E/PS2 (7.25V ac SCR supply).
E/PS2 drops.
Open 208V ac to B F/R pac, power tub B blowers, and C and D gate blowers.
1
Drop F-K3 (Console C pwr on) and A3B2.
Drop 7.25V ac to SCCU SCR indicator drivers.
RCU 2 pwr on
Yes
No
Drop F/K4 (SCR pwr on).
Open 208V ac to F/PS2 (7.25V ac SCR supply).
F/PS2 drops.
Open 208V ac to C F/R pac, power tub C blowers, and C and D gate blowers.
2
1
Outputs of B dc regs fall (+6V, -3V, and +3V).
Drop A3B3 and C1A7.
Drop C1A9, C1B9, and C1C9 (dc sense relays).
Console POWER CHECK indicator on.
2
Outputs of C dc regs fall (+6V, -3V, and +3V).
Drop A3E3 and C1B7.
Drop C1A9, C1B9, and C1C9 (dc sense relays).
Console POWER CHECK indicator on.
Drop C1C8 (Pwr on reset).
Console power-off sequence is complete.

Figure 8-27. SCCU Normal Power-Off Sequence Flowchart

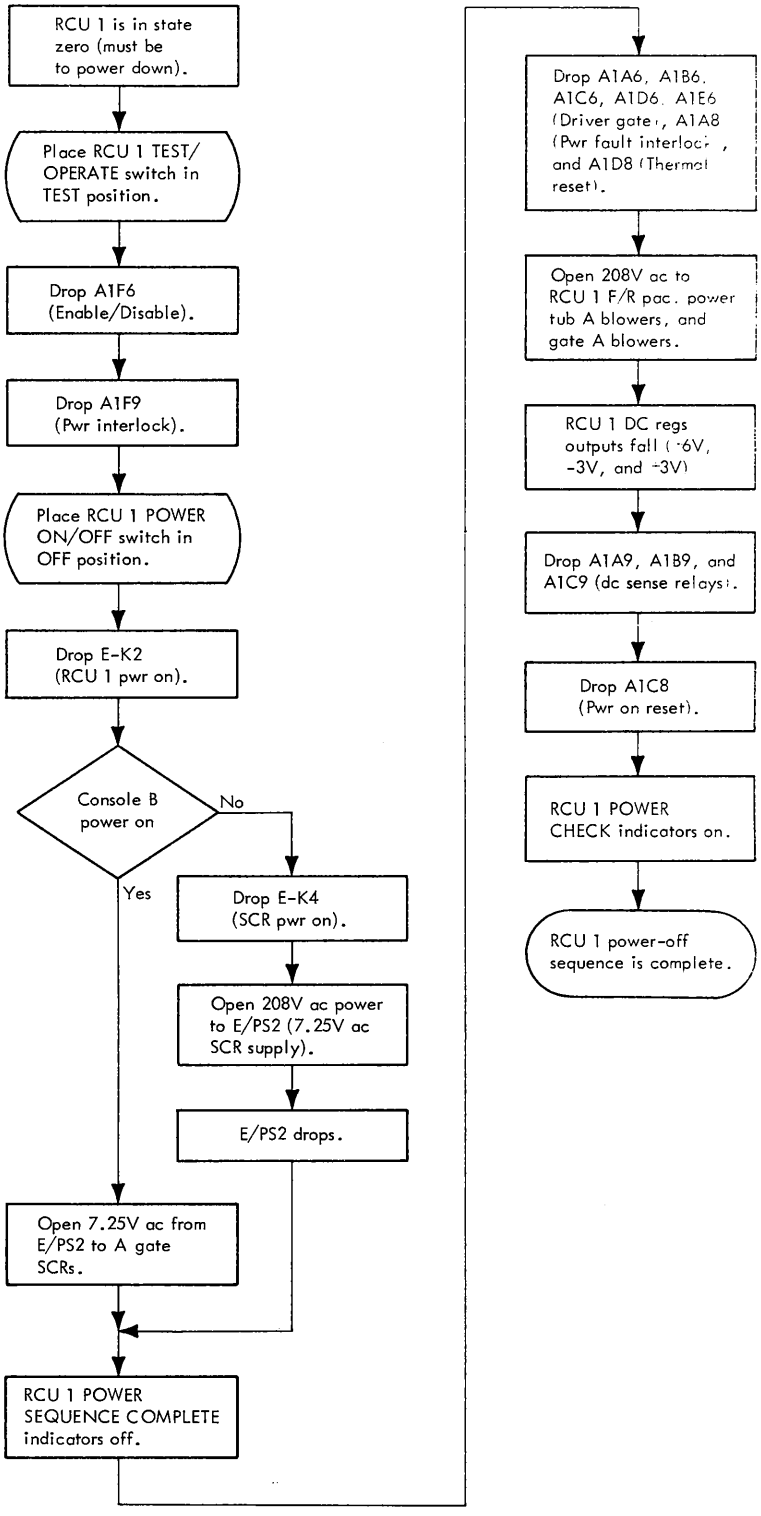

RCU 1 is in state zero (must be to power down).
Place RCU 1 TEST/ OPERATE switch in TEST position.
Drop A1F6 (Enable/Disable).
Drop A1F9 (Pwr interlock).
Place RCU 1 POWER ON/OFF switch in OFF position.
Drop E-K2 (RCU 1 pwr on).
Console B power on
No
Yes
Drop E-K4 (SCR pwr on).
Open 208V ac power to E/PS2 (7.25V ac SCR supply).
E/PS2 drops.
Open 7.25V ac from E/PS2 to A gate SCRs.
RCU 1 POWER SEQUENCE COMPLETE indicators off.
Drop A1A6, A1B6, A1C6, A1D6, A1E6 (Driver gate), A1A8 (Pwr fault interlock), and A1D8 (Thermal reset).
Open 208V ac to RCU 1 F/R pac. power tub A blowers, and gate A blowers.
RCU 1 DC regs outputs fall (+6V, -3V, and +3V)
Drop A1A9, A1B9, and A1C9 (dc sense relays).
Drop A1C8 (Pwr on reset).
RCU 1 POWER CHECK indicators on.
RCU 1 power-off sequence is complete.

Figure 8-28. RCU 1 Normal Power-Off Sequence Flowchart

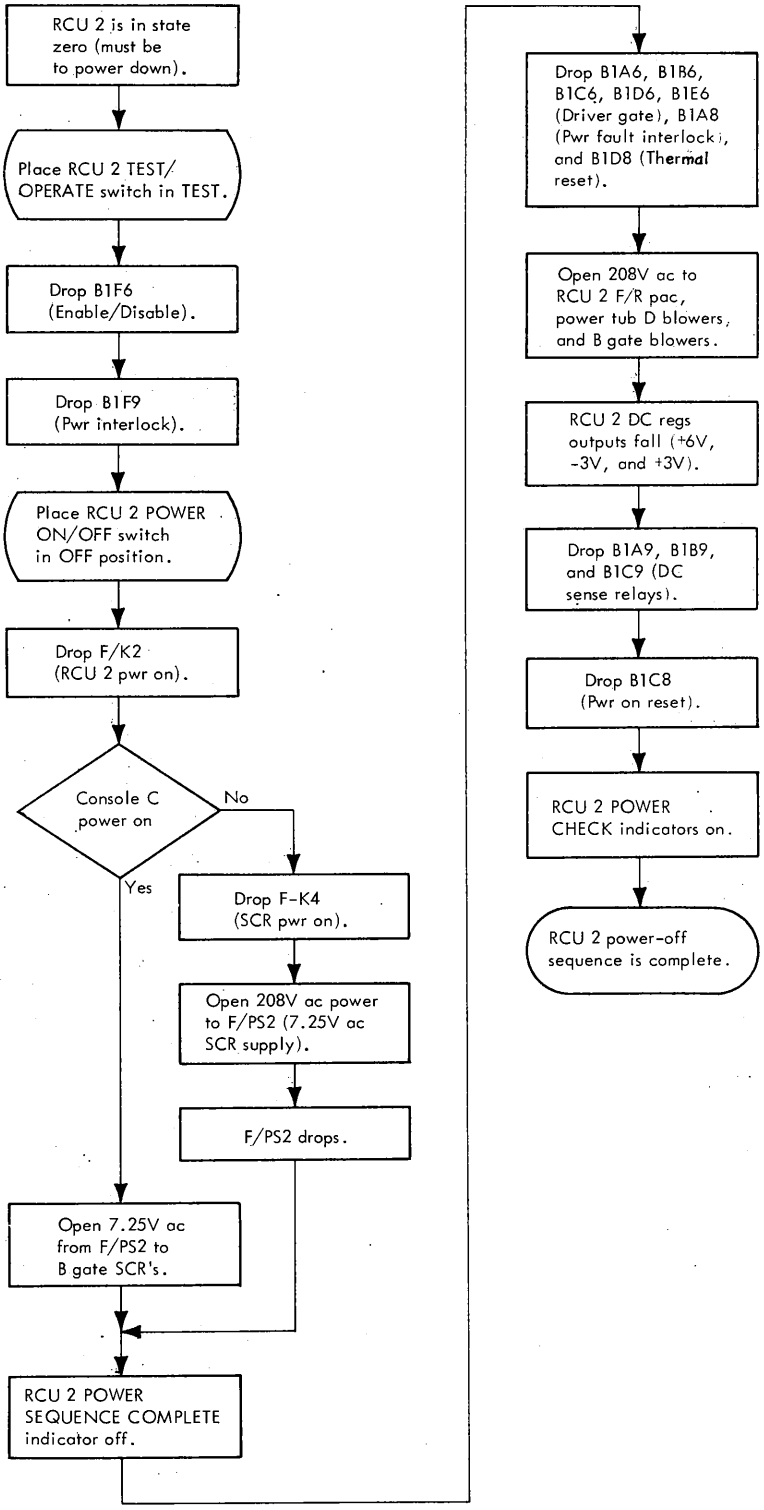

RCU 2 is in state zero (must be to power down).
Place RCU 2 TEST/ OPERATE switch in TEST.
Drop B1F6 (Enable/Disable).
Drop B1F9 (Pwr interlock).
Place RCU 2 POWER ON/OFF switch in OFF position.
Drop F/K2 (RCU 2 pwr on).
Console C power on
No
Yes
Drop F-K4 (SCR pwr on).
Open 208V ac power to F/PS2 (7.25V ac SCR supply).
F/PS2 drops.
Open 7.25V ac from F/PS2 to B gate SCR's.
RCU 2 POWER SEQUENCE COMPLETE indicator off.
Drop B1A6, B1B6, B1C6, B1D6, B1E6 (Driver gate), B1A8 (Pwr fault interlock), and B1D8 (Thermal reset).
Open 208V ac to RCU 2 F/R pac, power tub D blowers, and B gate blowers.
RCU 2 DC regs outputs fall (+6V, -3V, and +3V).
Drop B1A9, B1B9, and B1C9 (DC sense relays).
Drop B1C8 (Pwr on reset).
RCU 2 POWER CHECK indicators on.
RCU 2 power-off sequence is complete.

Figure 8-29. RCU 2 Normal Power-Off Sequence Flowchart

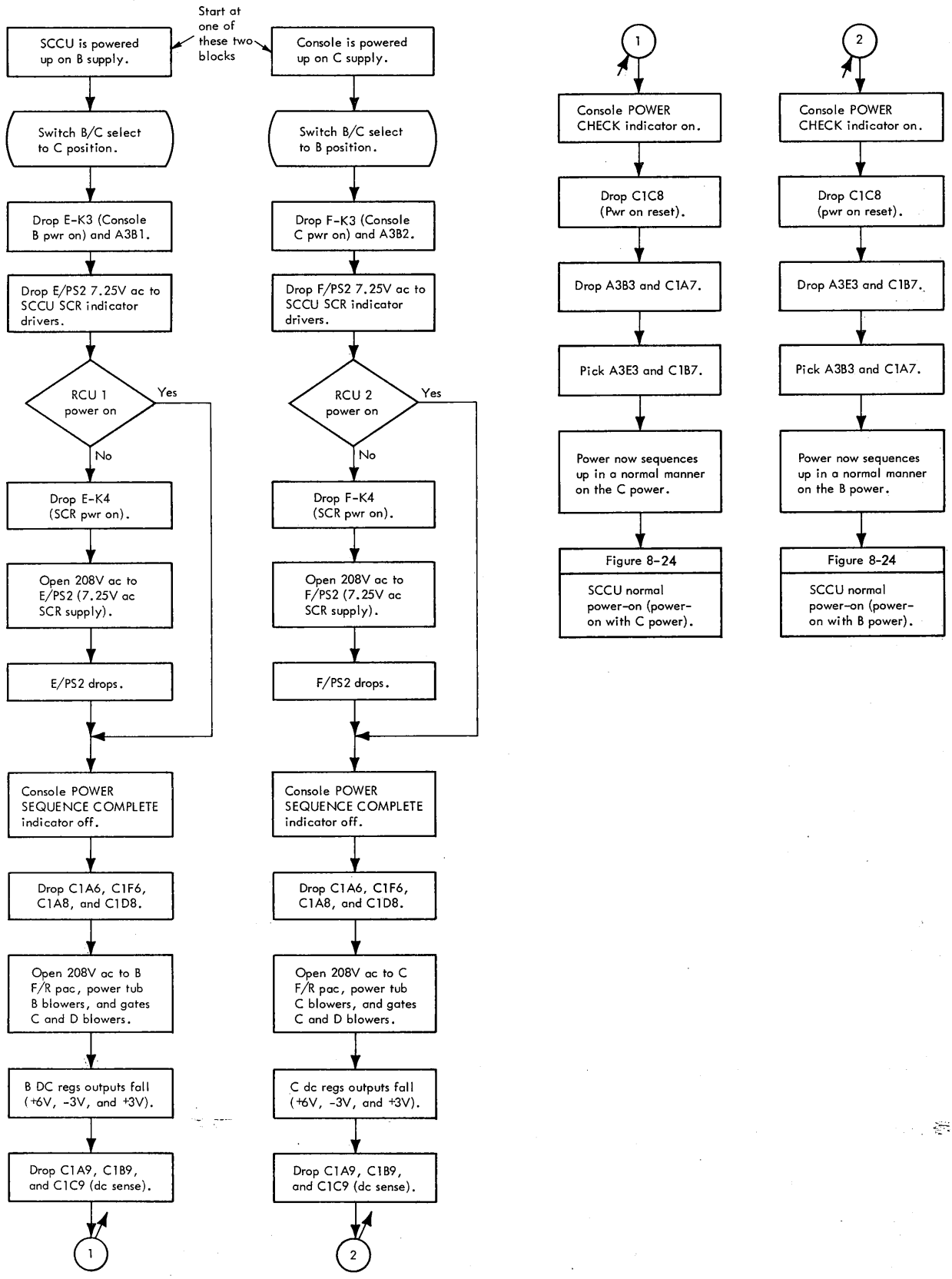

Start at one of these two blocks
SCCU is powered up on B supply.
Console is powered up on C supply.
Switch B/C select to C position.
Switch B/C select to B position.
Drop E-K3 (Console B pwr on) and A3B1.
Drop F-K3 (Console C pwr on) and A3B2.
Drop E/PS2 7.25V ac to SCCU SCR indicator drivers.
Drop F/PS2 7.25V ac to SCCU SCR indicator drivers.
RCU 1 power on
RCU 2 power on
Yes
No
Drop E-K4 (SCR pwr on).
Drop F-K4 (SCR pwr on).
Open 208V ac to E/PS2 (7.25V ac SCR supply).
Open 208V ac to F/PS2 (7.25V ac SCR supply).
E/PS2 drops.
F/PS2 drops.
Console POWER SEQUENCE COMPLETE indicator off.
Drop C1A6, C1F6, C1A8, and C1D8.
Open 208V ac to B F/R pac, power tub B blowers, and gates C and D blowers.
Open 208V ac to C F/R pac, power tub C blowers, and gates C and D blowers.
B DC regs outputs fall (+6V, -3V, and +3V).
C dc regs outputs fall (+6V, -3V, and +3V).
Drop C1A9, C1B9, and C1C9 (dc sense).
1
2
Console POWER CHECK indicator on.
Drop C1C8 (Pwr on reset).
Drop A3B3 and C1A7.
Pick A3E3 and C1B7.
Power now sequences up in a normal manner on the C power.
Figure 8-24
SCCU normal power-on (power-on with C power).
Console POWER CHECK indicator on.
Drop C1C8 (pwr on reset).
Drop A3E3 and C1B7.
Pick A3B3 and C1A7.
Power now sequences up in a normal manner on the B power.
Figure 8-24
SCCU normal power-on (power-on with B power).

Figure 8-30. SCCU Power Supply Switchover with Power On

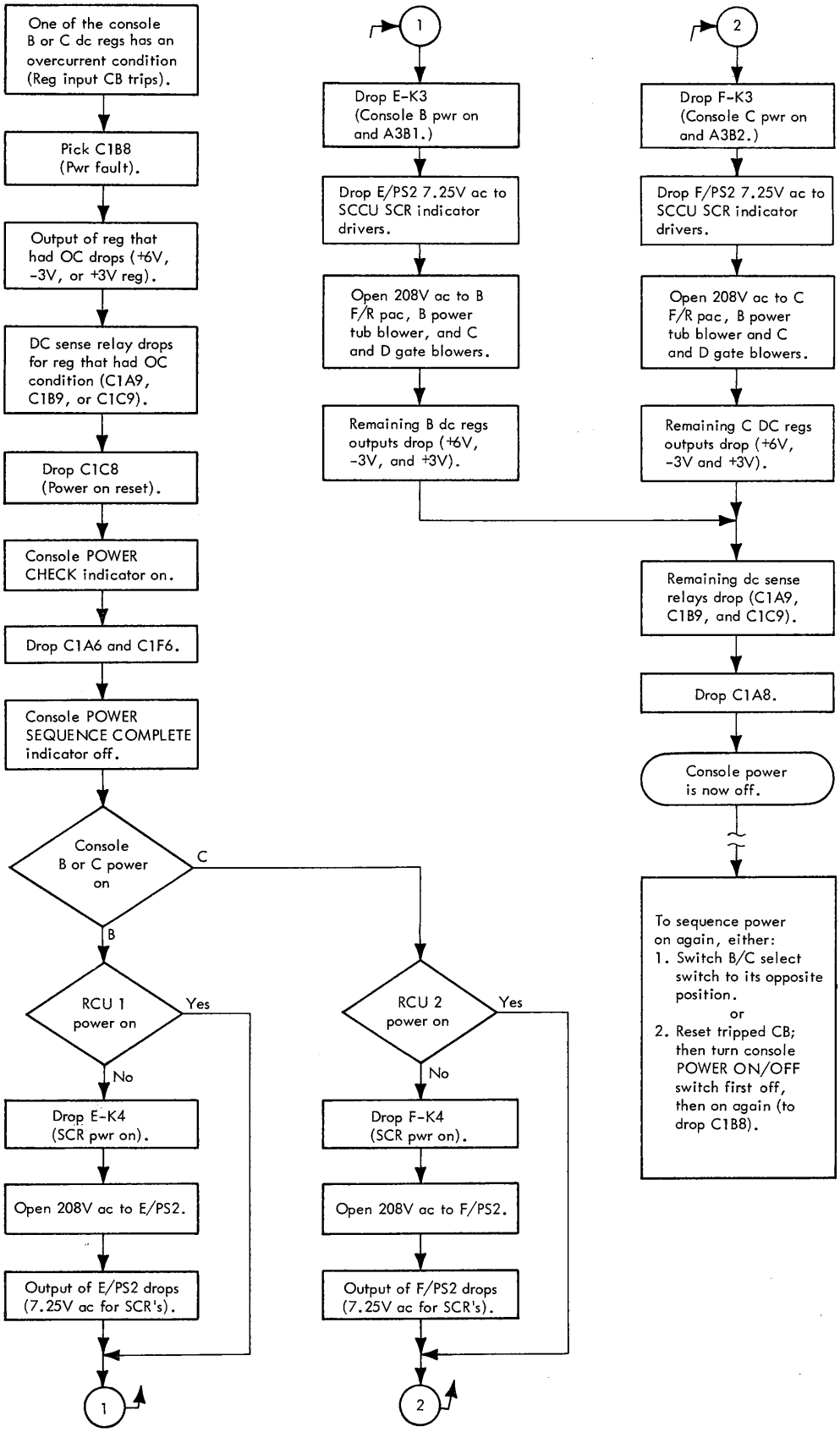

One of the console B or C dc regs has an overcurrent condition (Reg input CB trips).
Pick C1B8 (Pwr fault).
Output of reg that had OC drops (+6V, -3V, or +3V reg).
DC sense relay drops for reg that had OC condition (C1A9, C1B9, or C1C9).
Drop C1C8 (Power on reset).
Console POWER CHECK indicator on.
Drop C1A6 and C1F6.
Console POWER SEQUENCE COMPLETE indicator off.
Console B or C power on
C
B
RCU 1 power on
Yes
No
Drop E-K4 (SCR pwr on).
Open 208V ac to E/PS2.
Output of E/PS2 drops (7.25V ac for SCR's).
1
RCU 2 power on
Yes
No
Drop F-K4 (SCR pwr on).
Open 208V ac to F/PS2.
Output of F/PS2 drops (7.25V ac for SCR's).
2
1
Drop E-K3 (Console B pwr on and A3B1.)
Drop E/PS2 7.25V ac to SCCU SCR indicator drivers.
Open 208V ac to B F/R pac, B power tub blower, and C and D gate blowers.
Remaining B dc regs outputs drop (+6V, -3V, and +3V).
2
Drop F-K3 (Console C pwr on and A3B2.)
Drop F/PS2 7.25V ac to SCCU SCR indicator drivers.
Open 208V ac to C F/R pac, B power tub blower and C and D gate blowers.
Remaining C DC regs outputs drop (+6V, -3V and +3V).
Remaining dc sense relays drop (C1A9, C1B9, and C1C9).
Drop C1A8.
Console power is now off.
To sequence power on again, either:
1. Switch B/C select switch to its opposite position.
or
2. Reset tripped CB; then turn console POWER ON/OFF switch first off, then on again (to drop C1B8).

Figure 8-31. SCCU Overcurrent Power-Off Sequence Flowchart

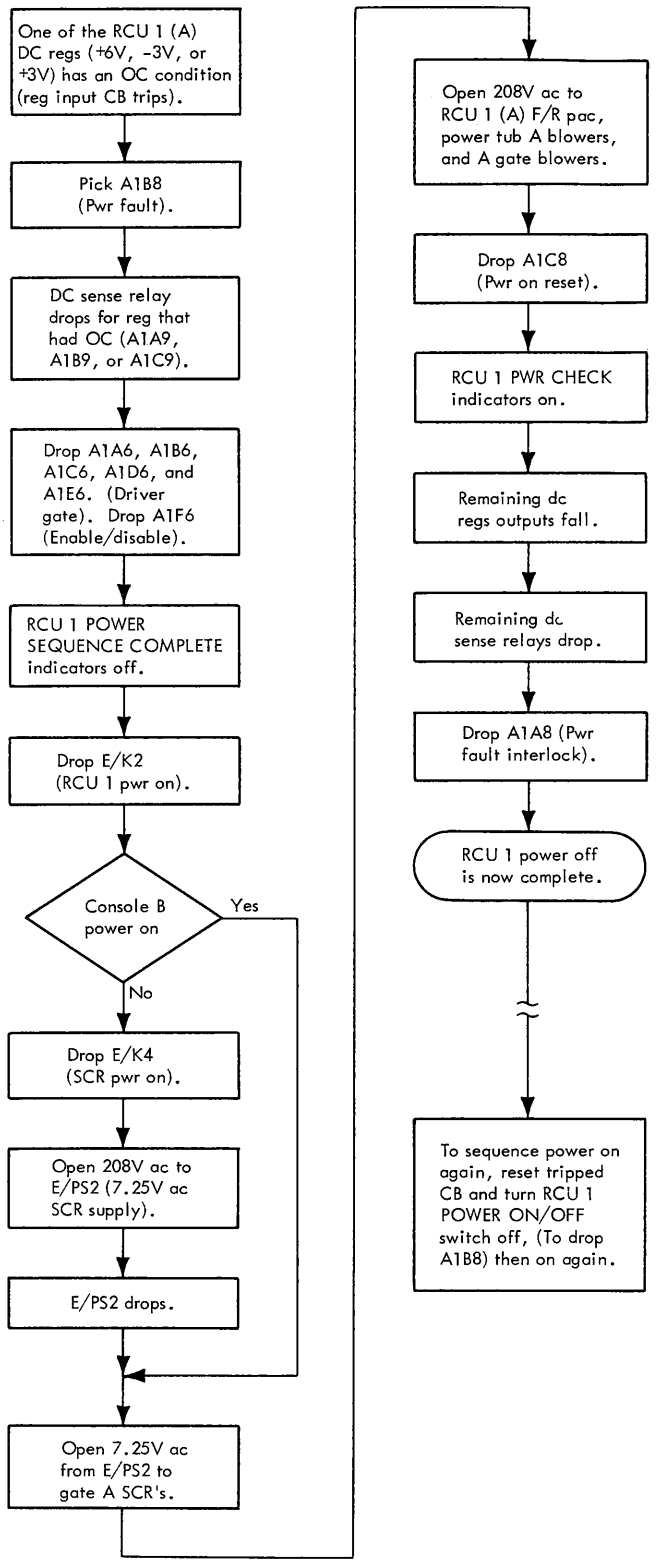
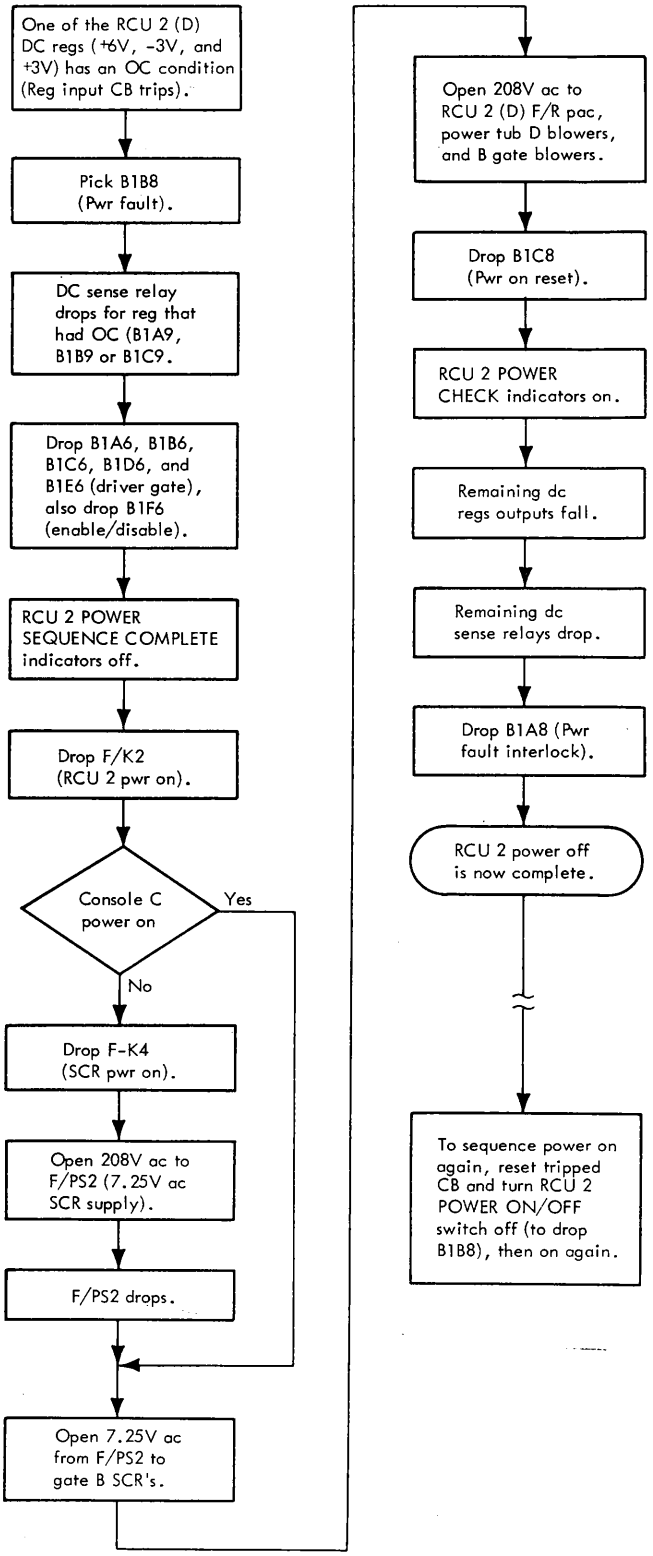

One of the RCU 1 (A) DC regs (+6V, -3V, or +3V) has an OC condition (reg input CB trips).
Pick A1B8 (Pwr fault).
DC sense relay drops for reg that had OC (A1A9, A1B9, or A1C9).
Drop A1A6, A1B6, A1C6, A1D6, and A1E6. (Driver gate). Drop A1F6 (Enable/disable).
RCU 1 POWER SEQUENCE COMPLETE indicators off.
Drop E/K2 (RCU 1 pwr on).
Console B power on
Yes
No
Drop E/K4 (SCR pwr on).
Open 208V ac to E/PS2 (7.25V ac SCR supply).
E/PS2 drops.
Open 7.25V ac from E/PS2 to gate A SCR's.
Open 208V ac to RCU 1 (A) F/R pac, power tub A blowers, and A gate blowers.
Drop A1C8 (Pwr on reset).
RCU 1 PWR CHECK indicators on.
Remaining dc regs outputs fall.
Remaining dc sense relays drop.
Drop A1A8 (Pwr fault interlock).
RCU 1 power off is now complete.
To sequence power on again, reset tripped CB and turn RCU 1 POWER ON/OFF switch off, (To drop A1B8) then on again.

Figure 8-32. RCU 1 Overcurrent Power-Off Sequence Flowchart


One of the RCU 2 (D) DC regs (+6V, -3V, and +3V) has an OC condition (Reg input CB trips).
Pick B1B8 (Pwr fault).
DC sense relay drops for reg that had OC (B1A9, B1B9 or B1C9.
Drop B1A6, B1B6, B1C6, B1D6, and B1E6 (driver gate), also drop B1F6 (enable/disable).
RCU 2 POWER SEQUENCE COMPLETE indicators off.
Drop F/K2 (RCU 2 pwr on).
Console C power on
Yes
No
Drop F-K4 (SCR pwr on).
Open 208V ac to F/PS2 (7.25V ac SCR supply).
F/PS2 drops.
Open 7.25V ac from F/PS2 to gate B SCR's.
Open 208V ac to RCU 2 (D) F/R pac, power tub D blowers, and B gate blowers.
Drop B1C8 (Pwr on reset).
RCU 2 POWER CHECK indicators on.
Remaining dc regs outputs fall.
Remaining dc sense relays drop.
Drop B1A8 (Pwr fault interlock).
RCU 2 power off is now complete.
To sequence power on again, reset tripped CB and turn RCU 2 POWER ON/OFF switch off (to drop B1B8), then on again.

●Figure 8-33. RCU 2 Overcurrent Power-Off Sequence Flowchart

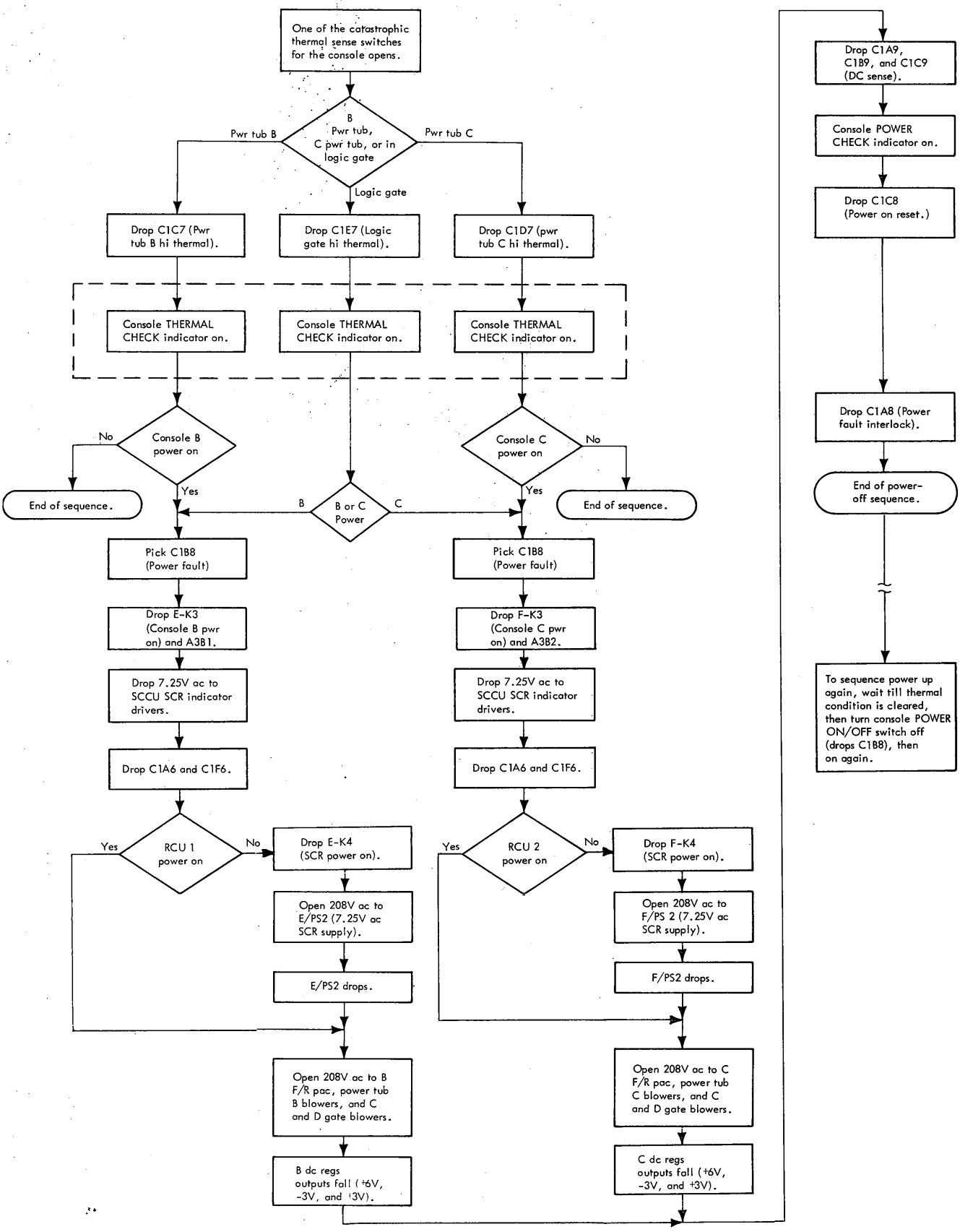

One of the catastrophic thermal sense switches for the console opens.
B Pwr tub, C pwr tub, or in logic gate
Pwr tub B
Pwr tub C
Logic gate
Drop C1C7 (Pwr tub B hi thermal).
Drop C1E7 (Logic gate hi thermal).
Drop C1D7 (pwr tub C hi thermal).
Console THERMAL CHECK indicator on.
Console THERMAL CHECK indicator on.
Console THERMAL CHECK indicator on.
No
Console B power on
Yes
End of sequence.
B
B or C Power
C
Console C power on
No
Yes
End of sequence.
Pick C1B8 (Power fault)
Drop E-K3 (Console B pwr on) and A3B1.
Drop 7.25V ac to SCCU SCR indicator drivers.
Drop C1A6 and C1F6.
Pick C1B8 (Power fault)
Drop F-K3 (Console C pwr on) and A3B2.
Drop 7.25V ac to SCCU SCR indicator drivers.
Drop C1A6 and C1F6.
Yes
RCU 1 power on
No
Drop E-K4 (SCR power on).
Open 208V ac to E/PS2 (7.25V ac SCR supply).
E/PS2 drops.
Yes
RCU 2 power on
No
Drop F-K4 (SCR power on).
Open 208V ac to F/PS 2 (7.25V ac SCR supply).
F/PS2 drops.
Open 208V ac to B F/R pac, power tub B blowers, and C and D gate blowers.
B dc regs outputs fall (+6V, -3V, and +3V).
Open 208V ac to C F/R pac, power tub C blowers, and C and D gate blowers.
C dc regs outputs fall (+6V, -3V, and +3V).
Drop C1A9, C1B9, and C1C9 (DC sense).
Console POWER CHECK indicator on.
Drop C1C8 (Power on reset.)
Drop C1A8 (Power fault interlock).
End of power-off sequence.
To sequence power up again, wait till thermal condition is cleared, then turn console POWER ON/OFF switch off (drops C1B8), then on again.

Figure 8-34. SCCU Catastrophic Thermal Power-Off Sequence Flowchart

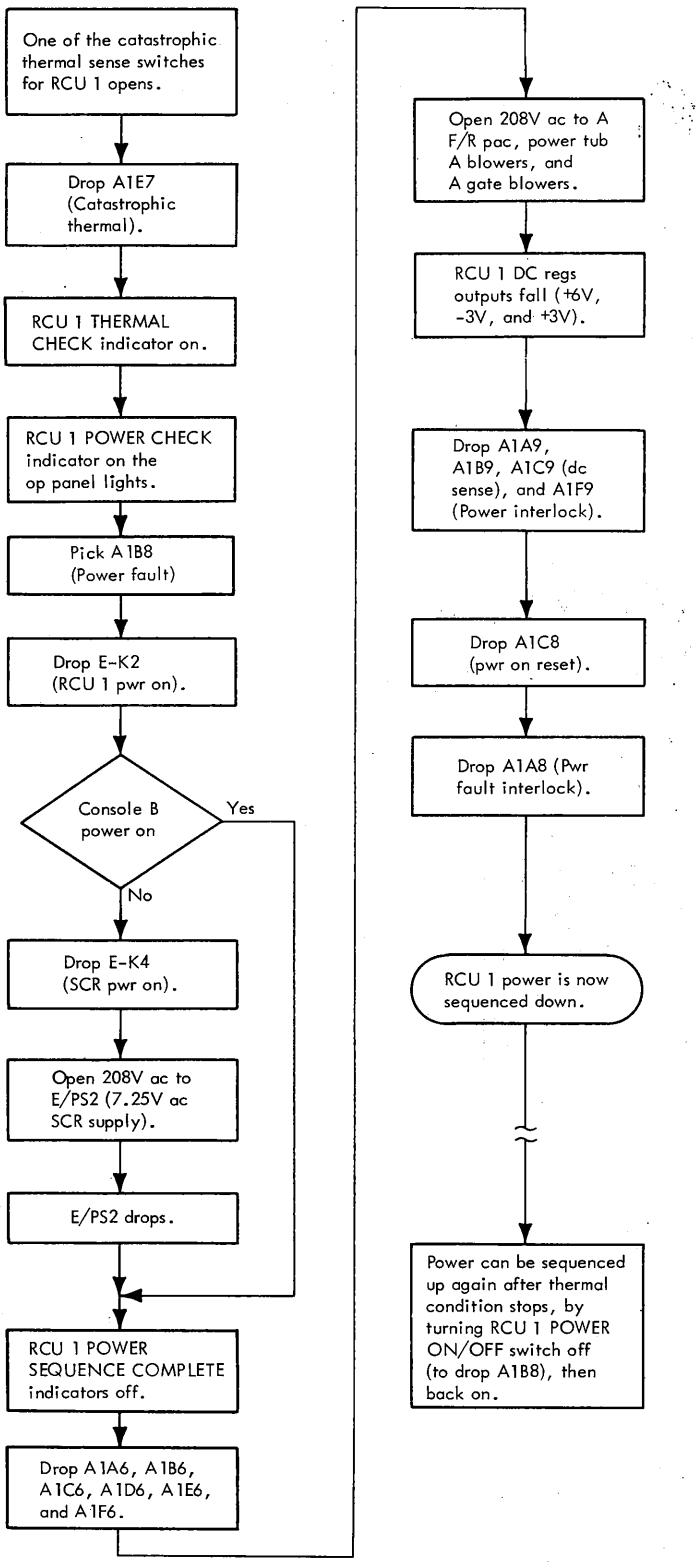

One of the catastrophic thermal sense switches for RCU 1 opens.
Drop A1E7 (Catastrophic thermal).
RCU 1 THERMAL CHECK indicator on.
RCU 1 POWER CHECK indicator on the op panel lights.
Pick A1B8 (Power fault)
Drop E-K2 (RCU 1 pwr on).
Console B power on
Yes
No
Drop E-K4 (SCR pwr on).
Open 208V ac to E/PS2 (7.25V ac SCR supply).
E/PS2 drops.
RCU 1 POWER SEQUENCE COMPLETE indicators off.
Drop A1A6, A1B6, A1C6, A1D6, A1E6, and A1F6.
Open 208V ac to A F/R pac, power tub A blowers, and A gate blowers.
RCU 1 DC regs outputs fall (+6V, -3V, and +3V).
Drop A1A9, A1B9, A1C9 (dc sense), and A1F9 (Power interlock).
Drop A1C8 (pwr on reset).
Drop A1A8 (Pwr fault interlock).
RCU 1 power is now sequenced down.
Power can be sequenced up again after thermal condition stops, by turning RCU 1 POWER ON/OFF switch off (to drop A1B8), then back on.

Figure 8-35. RCU 1 Catastrophic Thermal Power-Off Sequence Flowchart

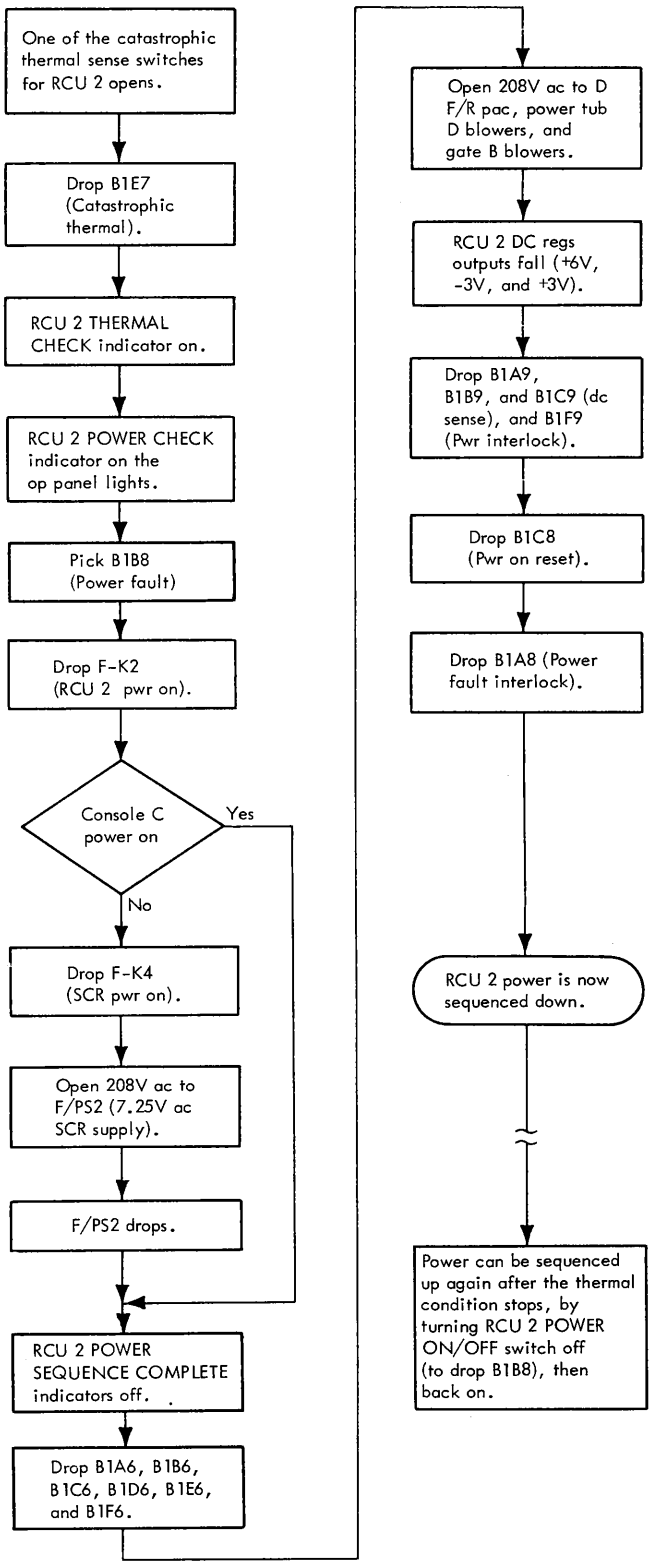

One of the catastrophic thermal sense switches for RCU 2 opens.
Drop B1E7 (Catastrophic thermal).
RCU 2 THERMAL CHECK indicator on.
RCU 2 POWER CHECK indicator on the op panel lights.
Pick B1B8 (Power fault)
Drop F-K2 (RCU 2 pwr on).
Console C power on
Yes
No
Drop F-K4 (SCR pwr on).
Open 208V ac to F/PS2 (7.25V ac SCR supply).
F/PS2 drops.
RCU 2 POWER SEQUENCE COMPLETE indicators off.
Drop B1A6, B1B6, B1C6, B1D6, B1E6, and B1F6.
Open 208V ac to D F/R pac, power tub D blowers, and gate B blowers.
RCU 2 DC regs outputs fall (+6V, -3V, and +3V).
Drop B1A9, B1B9, and B1C9 (dc sense), and B1F9 (Pwr interlock).
Drop B1C8 (Pwr on reset).
Drop B1A8 (Power fault interlock).
RCU 2 power is now sequenced down.
Power can be sequenced up again after the thermal condition stops, by turning RCU 2 POWER ON/OFF switch off (to drop B1B8), then back on.

Figure 8-36. RCU 2 Catastrophic Thermal Power-Off Sequence Flowchart

This chapter describes power control and distribution within the IBM 2803A SLT Tape Control Unit (TCU) as affected by the FAA modifications. Power distribution within the tape drives is discussed in IBM 2401 Tape Drive Theory of Operation manual.

POWER SEQUENCE AND CONTROL

Power Component Locations

- The operator's control panel provides monitoring and control functions.
- The prime power area includes a power supply and a prime power box with control functions.

Figures 9-1 through 9-4 show the TCU and its operator's control panel, maintenance panel, and prime power area.

The operator's panel (Figure 9-2) contain the following controls and indicators that concern power:

1. An ac power on/off switch (POWER ON/OFF).
2. A DC ON/OFF switch.
3. A METER ON/OFF switch.
4. A LAMP TEST pushbutton switch.
5. An ELEMENT MPO PULL switch.
6. A POWER CHECK indicator.
7. A THERMAL CHECK indicator.
8. A POWER SEQUENCE COMPLETE indicator.
9. Two STATE indicators.

The maintenance panel (Figure 9-3) includes one control that concerns power. It is the OFF-LINE jack which performs the same function as the METER ON/OFF switch on the operator's panel.

The prime power area (Figure 9-4) contains a power supply and prime power box. The power supply contains five dc regulators, five CBs (CB1–CB5), fuses (F5, F6, and F7), and a fan. The power supply provides voltages necessary for operation of the tape control unit. Each tape drive provides all dc voltages that it requires within its framework.

The prime power box contains a +24V dc prime supply, CBs, relays and contactors, fuses, a 115V step-down transformer and 115V convenience outlets, and a power control panel. The latter contains indicators to show ac on and power check, switches to turn ac on/off and dc on/off, and pushbuttons for reset and to test OTC. This panel also contains the EPO jack to connect the TCU to the system or configuration console.

Power Interlock Circuit

- Each TCU is power-interlocked with the system or configuration console.
- All main power is removed from the TCU under EPO/MPO conditions.

Power interlocking is such that all main TCU power can be removed under EPO/MPO conditions. Pulling the EPO switch on the console removes power from all elements; pulling the TCU MPO switch removes power only from that TCU.

Figure 9-5 shows the TCU interlock circuitry. Under normal or EPO/MPO power-off conditions, a +24V dc service voltage is still available between all elements and the system or configuration console. With the EPO switch closed at the console, the TCU (or any element) can pick and hold the EPO contactor. In the TCU, this circuit is from the +24V dc power source, through an isolation diode, to the console, through the EPO switches and EPO relay coil, and to the 24V dc return.

The EPO contactor in the console provides a pick circuit for the MPO contactor in the TCU. This circuit is through the MPO switch and MPO contactor K17, to the console, through the EPO N/O contacts, and to the 24V dc return.

AC Distribution

- 208V, 3-phase, 60-Hz input power.
- The TCU supplies ac power to the external tape drives.
- Under normal power-off conditions (the AC ON/OFF switches set to ON), 208V ac power is available to the +24V prime power supply and to the two banks of external tape drives.
- 115V ac is available to the convenience outlets.

The ac input consists of 3-phase, 208V, 60-Hz power that is routed directly from the facility service outlet (Figure 9-6).

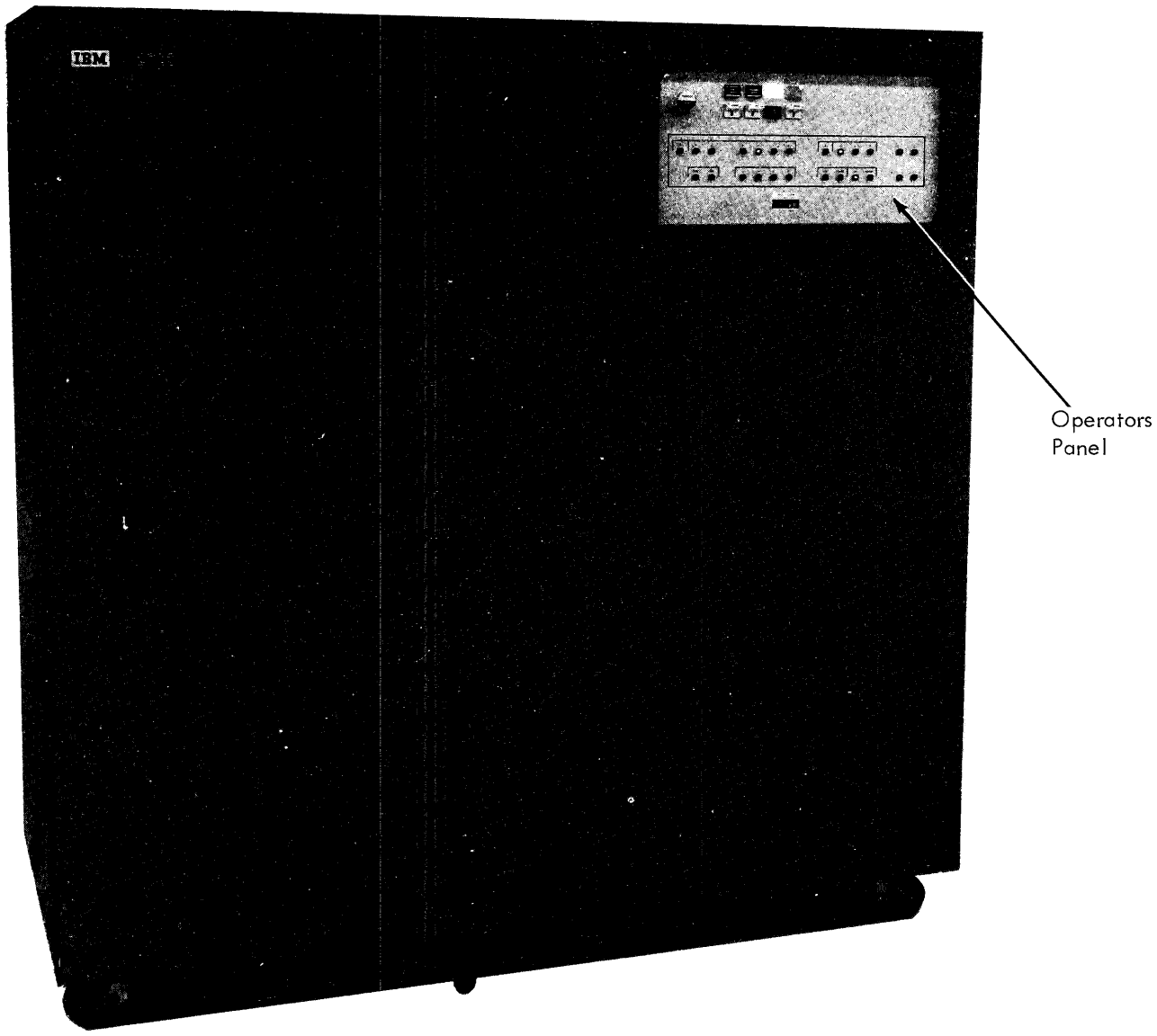


Figure 9-1. IBM 2803A Tape Control Unit

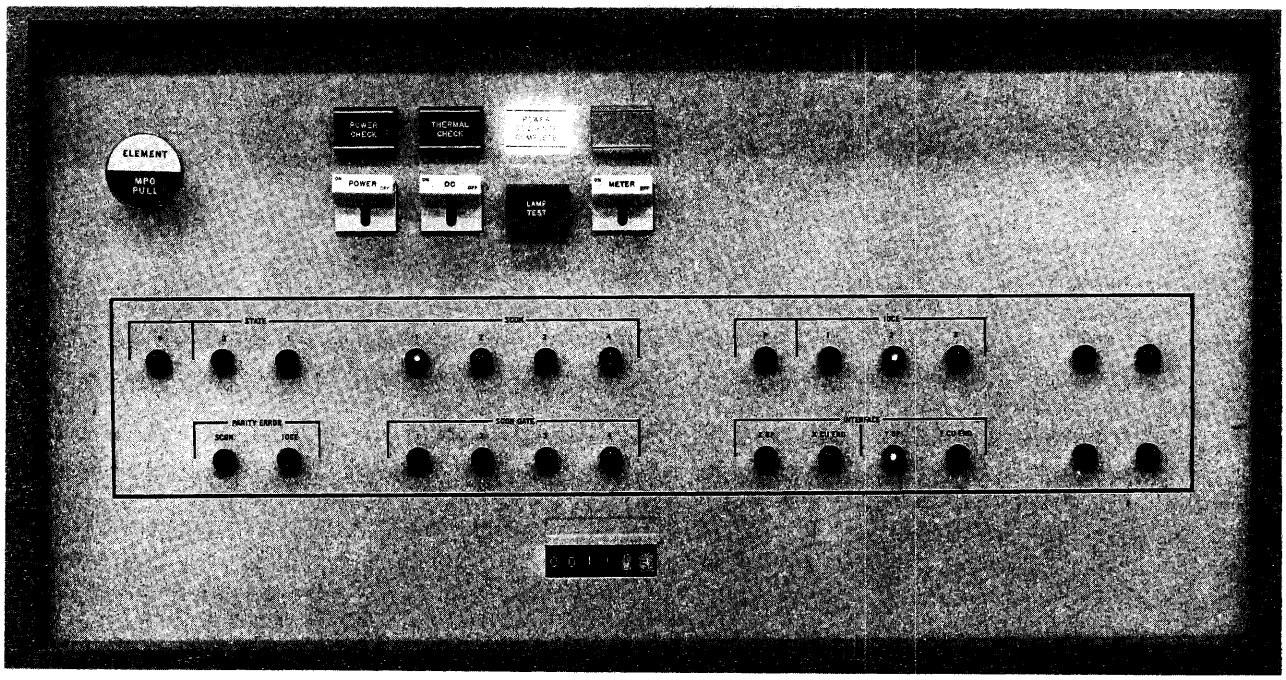


Figure 9-2. TCU Operator's Control Panel

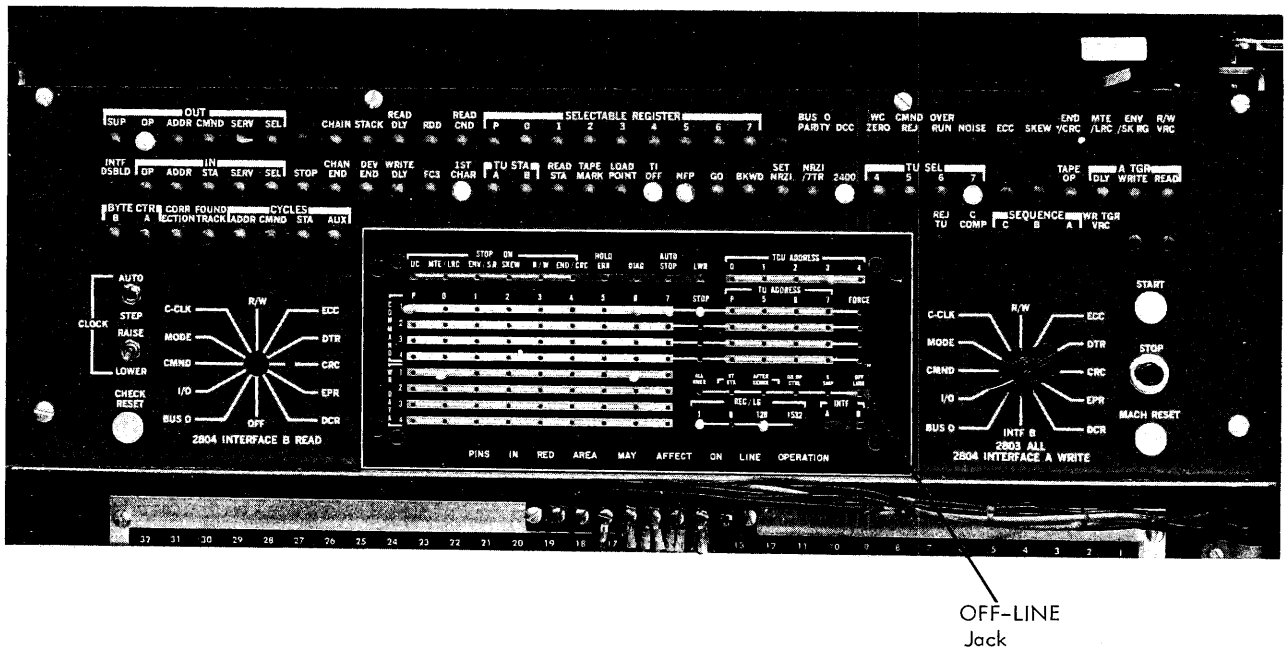


Figure 9-3. TCU Maintenance Panel

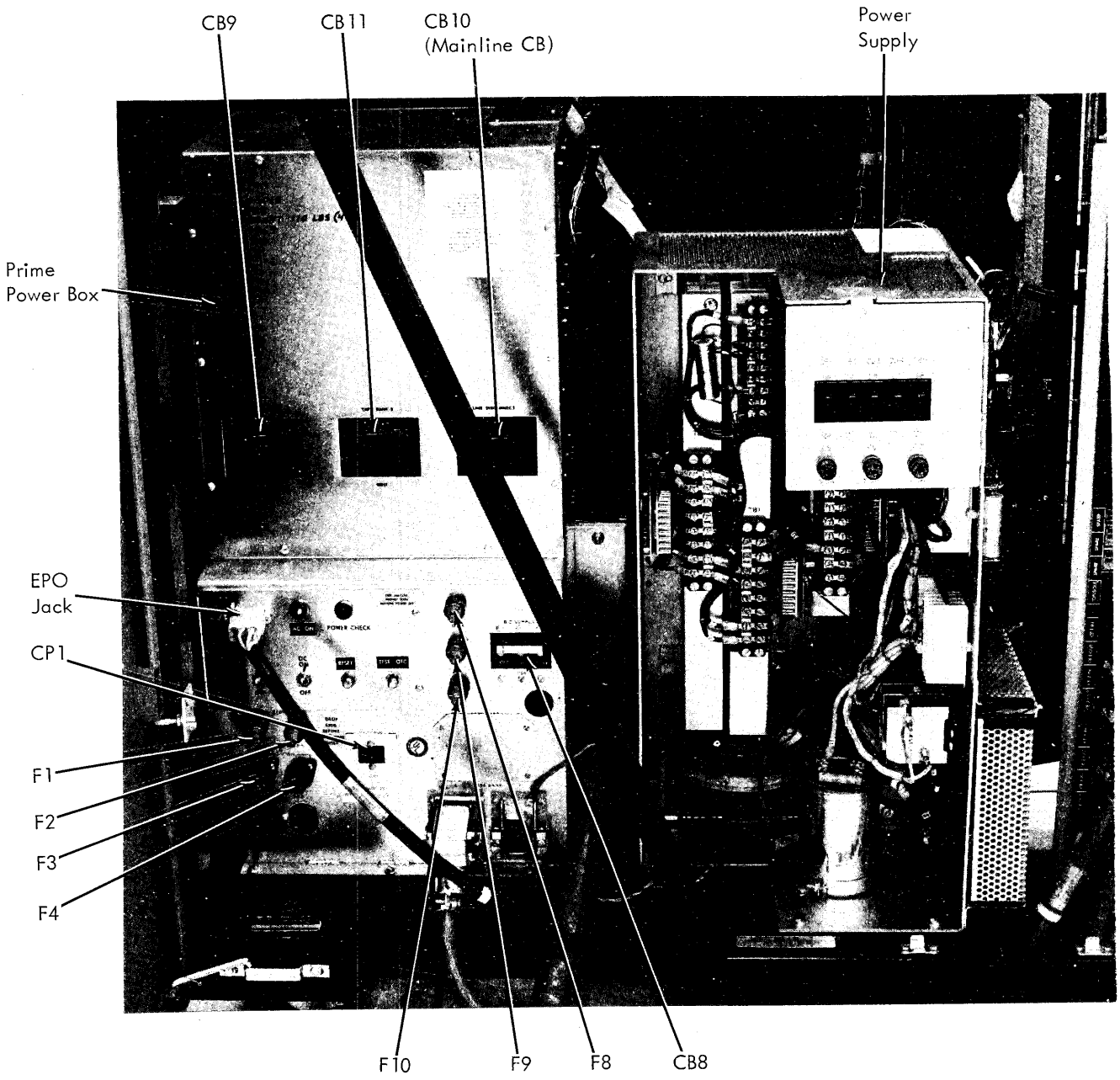
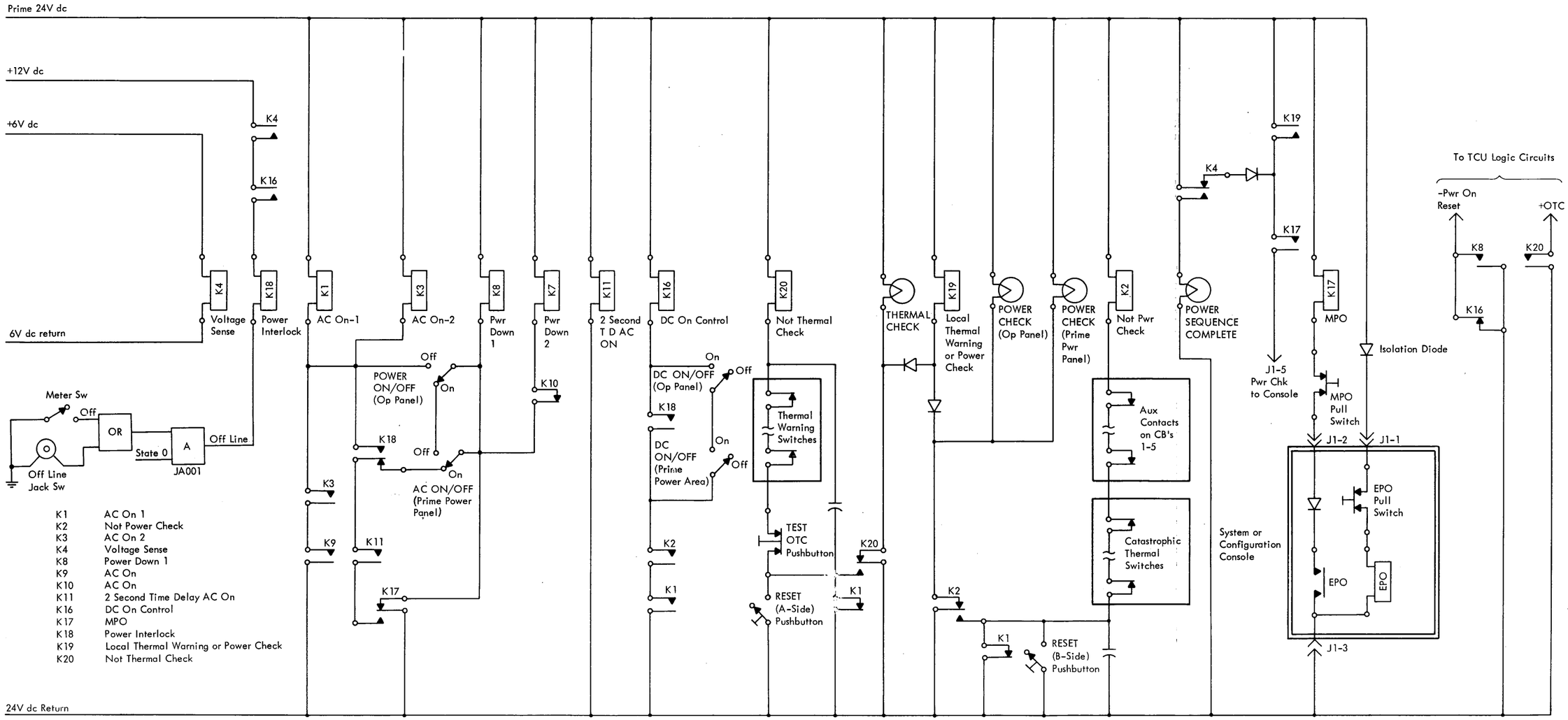


Figure 9-4. TCU Prime Power Area



●Figure 9-5. TCU Power Sequence and Control Circuitry

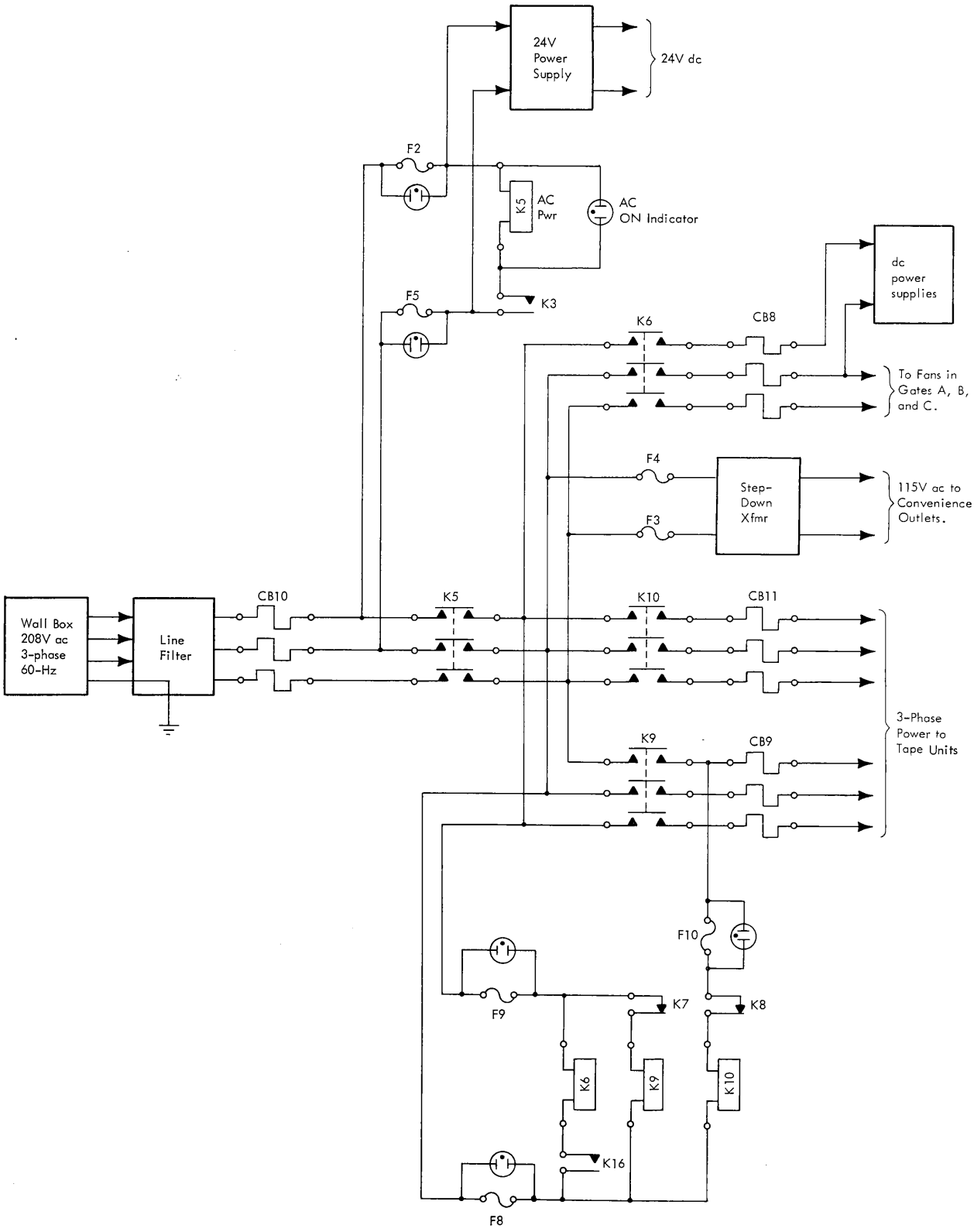


Figure 9-6. TCU AC Distribution

Closing main ac CB10 supplies 208V ac, single-phase power to the +24V dc prime power supply. Before further ac distribution can occur, the power-interlock circuit must be completed to the console as described in the preceding section.

With the power-interlock circuit complete, K1 (ac on-1) and K3 (ac on-2) can be picked when the AC ON/OFF switches are closed (Figure 9-5). The K3 relay points provide a pick circuit for contactor K5 (ac on) and light the AC ON indicator. When K5 picks, its N/O points provide 115V ac to the convenience outlets and pick contactor K9 (tape line 1 on). When K9 picks, its N/O points provide 208V ac power to one bank of tape drives through CB9, pick contactor K10 (tape line 2 on), and provide a hold circuit for K1 and K3. When K10 picks, its N/O contacts provide 208V ac power to the other bank of tape drives through CB11.

Before a further distribution of ac can occur, contactor K6 (dc on) must be picked. It is picked through the N/O points of K16 (dc on control). To pick K16, the DC ON/OFF switches must be turned on. When contactor K6 is picked, it supplies 208V ac to the multivolt power supply and to the gate fans through CB8.

DC Distribution

- All dc power (except 24V) is supplied by a single power supply.
- Five regulators are used in the TCU: +12V, -12V, +6V, +3V, and -3V.
- Each tape drive has a dc power supply.

The 2803A Tape Control Unit (TCU) uses modified power supplies to furnish the following dc voltages: +12V at 8 amp, -12V at 12 amp, +6V at 26 amp, +3V at 45 amp, and -3V at 6 amp. It also furnishes 7.25V ac for the indicators and 48V ac. Operation of power supplies is described in IBM Field Engineering Theory of Operation, SLT Power Supplies. Table 9-1 lists these supplies and their tolerances.

Power-On Sequence

- The ac power to the tape drives and dc power to the TCU can be controlled separately.
- The ac power-on portion is controlled by the AC ON/OFF switches.
- The dc power-on portion is controlled by the DC ON/OFF switches.

Refer to the ac distribution diagram (Figure 9-6), power sequence and control diagram (Figure 9-5), and power-on flowchart (Figure 9-7).

Before a power-on sequence can be started, the input circuit breaker, CB10, must be closed and system EPO contactor and ELEMENT MPO contactor K17 must be energized (Figure 9-5). With the AC ON/OFF switches and the DC ON/OFF switches set to the OFF position, the following conditions exist before the power-on sequence begins:

1. Relay K11 (ac on TD) is picked after the initial 2-second time delay, following main power through CB10.
2. If all thermal elements and CB side switches are in their N/C positions, K2 (not power check) and K20 (not thermal warning) are picked through a K1 N/C point and held through their own N/C points (Figure 9-5). The pick of these two relays energizes K19 (thermal warning power check) and resets the '+ thermal check' line to the TCU logic circuits, but does not remove the POWER CHECK indication from the console.

The ac portion of the power-on sequence can be started by closing the AC ON/OFF switches (one on the operator's panel labeled POWER ON/OFF and the other on the rear panel labeled AC ON/OFF). These two switches, in series with the K11 N/O, K18 N/C, and K17 N/O points, provide a pick circuit for K3 (ac on-2) and K1 (ac on-1). The K3 N/O points (Figure 9-6) light the AC ON indicator and pick contactor K5 (ac power-on). Picking this contactor provides a pick circuit for contactor K9 (tape line 1 on) and provides a 115V ac for the convenience outlets from the step-down transformer. When K9 picks, it provides 208V ac to tape bank 1 and picks contactor K8 (tape line 2 on). When K8 picks, it provides 208V ac to tape bank 2.

The dc portion of the power-on sequence can be started by closing the DC ON/OFF switches (one on the operator's panel and the other on the rear panel). The two switches, in series with the K1 N/O and K2 N/O points, complete a pick circuit for K16 (dc on control). When K16 picks, its contacts provide a pick circuit for contactor K6 (dc power on) and reset the '-Power on reset' line to the TCU logic circuit. When K6 picks, it gates 208V ac to the dc power supplies and the logic gate fans.

As the power supply voltages come up and the +6V dc output reaches operating level, K4 (voltage sense) picks to indicate that the power sequence is complete. When K4 picks, its points turn on the POWER SEQUENCE COMPLETE indicator on the TCU operator's panel and turn off the POWER CHECK indicator at the console operator's panel.

After power comes up, the TCU is in operational state zero. Relay K18 (power interlock) picks if the METER ON/OFF switch on the operator's panel is set at the ON position and if the OFF-LINE jack on the maintenance

Table 9-1. Power Supply Voltages

Voltage	Color Code	Regulation	Allowable Voltage Drop at B Gate TB	Allowable Voltage Drop, other TC Gates	Amperes
+12	Gray	±2%	0.24 (±2%)	±4%	8.0
-12	Violet	±2%	0.24 (±2%)	±4%	11.0
+6	Orange	±2%	0.12 (±2%)	±4%	24.0
+3		±2%	0.06 (±2%)	±4%	37.0
-3		±2%	0.06 (±2%)	±4%	6.0
7.25 ac		None	Not Specified		5.0

panel is not plugged. The K18 N/O points form parallel paths that effectively disable the AC ON/OFF and the DC ON/OFF switches. If the EXC program configures the TCU out of state zero, power cannot be removed (except under EPO/MPO conditions) without requesting a reconfiguration back to state zero.

Normal Power-Off Sequence

- The TCU must be in state zero and in an off-line status to begin a normal power-off sequence.
- All dc power (except 24V) can be removed with either DC ON/OFF switch.
- The ac power to the tape drives can be removed with either AC ON/OFF switch.

Refer to Figures 9-5, 9-6, and 9-8. To begin a normal power-off sequence, the TCU must be in state zero and in an off-line status. The most common means of placing the TCU in off-line status is to switch the METER ON/OFF switch on the operator's panel to OFF. The OFF-LINE jack on the maintenance panel can also be plugged to obtain the off-line status, but the front cover of the unit must be opened to do this. These two power-interlock conditions allow relay K18 (power interlock) to drop through logic circuitry and open the hold circuits in parallel with the AC and DC ON/OFF switches (Figure 9-5).

The ac power to the TCU and external tape drives can be removed by switching either of the AC ON/OFF switches to OFF (Figure 9-5). This operation immediately picks relays K8 (power down 1) and K7 (power down 2). When these relays are picked, they drop contactors K10 (tape line 2 on) and K9 (tape line 1 on), respectively. Power is thus removed from the two banks of tape drives. As K9 drops, it removes the pick circuit for K1 (ac on 1) and K3 (ac on 2), and these relays drop out. When K3 drops, it opens the circuit for contactor K5, and K5 drops out. When K5 drops out, all power except +24V dc prime is removed from the TCU.

Note that even though the AC ON/OFF and DC ON/OFF switches are in the OFF position the +24V dc prime power supply is still active. This +24V feeds the power-interlock cable to the console and keeps K17 (MPO) picked in the TCU. This +24V supply also feeds the power sequence and control circuitry in the TCU so that K11 (ac on TD), K2 (not power check), and K20 (not thermal warning) remain picked. Complete power can be removed only by opening CB10 or turning off the facility service outlet.

Emergency Power-Off Sequence

- EPO/MPO conditions immediately remove all power except the +24V dc supply.

If either the system EPO or the TCU MPO pull switch is pulled, all power is removed beyond the prime power box, except the prime +24V dc supply. These EPO/MPO switches are mechanical-interlock switches that must be reset manually.

This emergency power-off sequence is similar to that of switching one of the AC ON/OFF switches to the OFF position. The only difference is that the power-interlock circuit (K18) has no effect, and power sequences off independently of the state of the TCU logic circuitry.

Under EPO/MPO conditions, +24V dc is still available within the power-interlock cable that connects the TCU and the console. This voltage is necessary so that power can automatically sequence up when the EPO/MPO condition is removed.

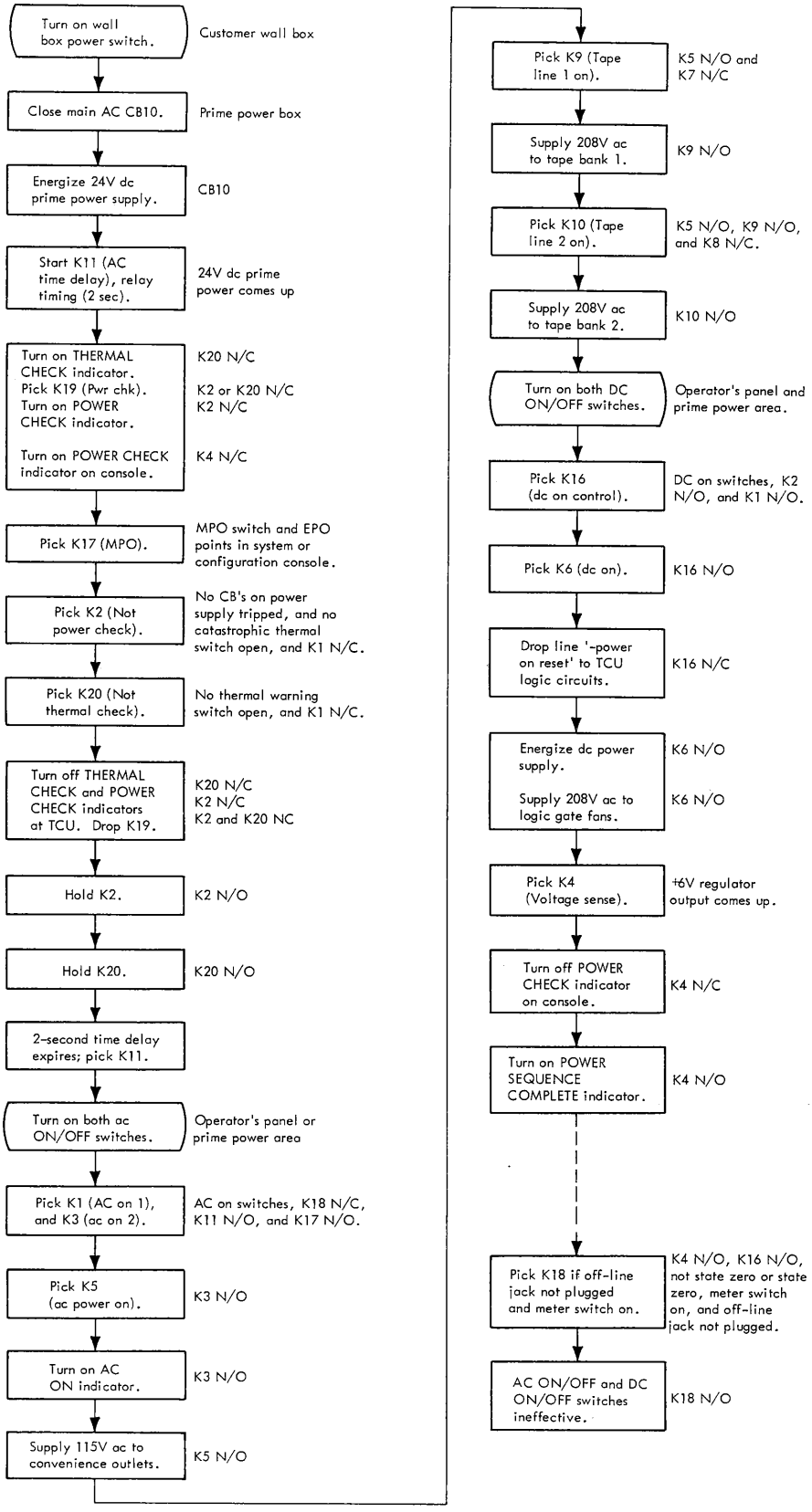

Turn on wall box power switch.
Customer wall box
Close main AC CB10.
Prime power box
Energize 24V dc prime power supply.
CB10
Start K11 (AC time delay), relay timing (2 sec).
24V dc prime power comes up
Turn on THERMAL CHECK indicator.
K20 N/C
Pick K19 (Pwr chk).
K2 or K20 N/C
Turn on POWER CHECK indicator.
K2 N/C
Turn on POWER CHECK indicator on console.
K4 N/C
Pick K17 (MPO).
MPO switch and EPO points in system or configuration console.
Pick K2 (Not power check).
No CB's on power supply tripped, and no catastrophic thermal switch open, and K1 N/C.
Pick K20 (Not thermal check).
No thermal warning switch open, and K1 N/C.
Turn off THERMAL CHECK and POWER CHECK indicators at TCU. Drop K19.
K20 N/C
K2 N/C
K2 and K20 NC
Hold K2.
K2 N/O
Hold K20.
K20 N/O
2-second time delay expires; pick K11.
Turn on both ac ON/OFF switches.
Operator's panel or prime power area
Pick K1 (AC on 1), and K3 (ac on 2).
AC on switches, K18 N/C, K11 N/O, and K17 N/O.
Pick K5 (ac power on).
K3 N/O
Turn on AC ON indicator.
K3 N/O
Supply 115V ac to convenience outlets.
K5 N/O
Pick K9 (Tape line 1 on).
K5 N/O and K7 N/C
Supply 208V ac to tape bank 1.
K9 N/O
Pick K10 (Tape line 2 on).
K5 N/O, K9 N/O, and K8 N/C.
Supply 208V ac to tape bank 2.
K10 N/O
Turn on both DC ON/OFF switches.
Operator's panel and prime power area.
Pick K16 (dc on control).
DC on switches, K2 N/O, and K1 N/O.
Pick K6 (dc on).
K16 N/O
Drop line '-power on reset' to TCU logic circuits.
K16 N/C
Energize dc power supply.
K6 N/O
Supply 208V ac to logic gate fans.
K6 N/O
Pick K4 (Voltage sense).
+6V regulator output comes up.
Turn off POWER CHECK indicator on console.
K4 N/C
Turn on POWER SEQUENCE COMPLETE indicator.
K4 N/O
Pick K18 if off-line jack not plugged and meter switch on.
K4 N/O, K16 N/O, not state zero or state zero, meter switch on, and off-line jack not plugged.
AC ON/OFF and DC ON/OFF switches ineffective.
K18 N/O

Figure 9-7. TCU Power-On Flowchart

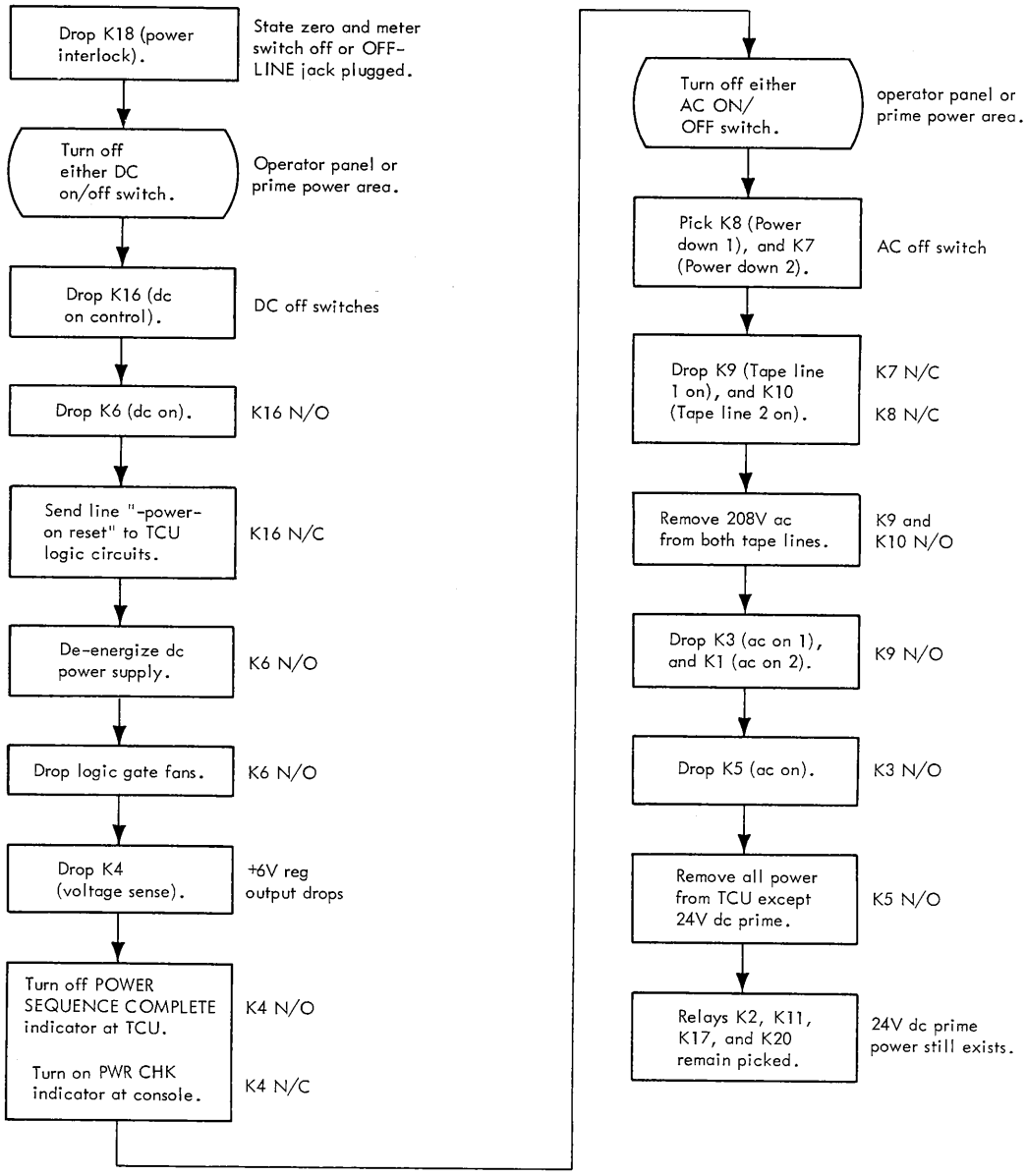

Drop K18 (power interlock).
State zero and meter switch off or OFF-LINE jack plugged.
Turn off either DC on/off switch.
Operator panel or prime power area.
Drop K16 (dc on control).
DC off switches
Drop K6 (dc on).
K16 N/O
Send line "-power-on reset" to TCU logic circuits.
K16 N/C
De-energize dc power supply.
K6 N/O
Drop logic gate fans.
K6 N/O
Drop K4 (voltage sense).
+6V reg output drops
Turn off POWER SEQUENCE COMPLETE indicator at TCU.
K4 N/O
Turn on PWR CHK indicator at console.
K4 N/C
Turn off either AC ON/ OFF switch.
operator panel or prime power area.
Pick K8 (Power down 1), and K7 (Power down 2).
AC off switch
Drop K9 (Tape line 1 on), and K10 (Tape line 2 on).
K7 N/C
K8 N/C
Remove 208V ac from both tape lines.
K9 and K10 N/O
Drop K3 (ac on 1), and K1 (ac on 2).
K9 N/O
Drop K5 (ac on).
K3 N/O
Remove all power from TCU except 24V dc prime.
K5 N/O
Relays K2, K11, K17, and K20 remain picked.
24V dc prime power still exists.

Figure 9-8. TCU Power-Off Flowchart

Special Power-Off Sequences

Two categories of special power-off sequences are described below. These sequences result from the detection of a power-check (overcurrent) condition of a dc regulator or an overtemperature (thermal) condition in a logic gate.

Power Check (Overcurrent) Power-Off Sequence

- An overcurrent condition causes a normal dc power-off sequence.
- Power does not sequence up until either the RESET pushbutton or the AC ON/OFF switch is operated.

Circuit breakers 1 through 5 (in the power supply assembly) provide protection against an overcurrent (OC) condition in the +12V, -12V, +6V, +3V, and -3V regulators. An OC condition in any of these regulators causes its respective circuit breaker to open (Figure 9-5), which drops relay K2 (not power check).

The K2 N/O points open the circuit to K6 (dc on control), and a normal dc power-off sequence is started. The K2 N/C points turn on POWER CHECK indicators at the TCU, and a 'power check' is sent to the console through the K4 N/C points and the K17 N/O points.

After the OC condition is corrected, power can be cycled up by depressing the RESET pushbutton (Figure 9-5). This picks K2 which turns off the POWER CHECK indicators and drops K19 through K2 N/C. Relay K16 (dc on control) picks through the K2 points, and a normal power-on sequence occurs.

Thermal Check Power-Off Sequence

- A warning temperature condition does not sequence power-off.
- A catastrophic temperature condition starts a dc power-off sequence.
- Power does not sequence up until the catastrophic thermal condition is resolved and relay K2 (not power check) is picked.

Two thermal checks (warning and catastrophic) can occur in the TCU. The first check (warning) occurs when the TCU operating temperature in any of the logic gates is between 122°F and 134°F. When any of these thermal sensors opens (Figure 9-5), K20 (not thermal check) drops.

The K20 N/C points turn on the THERMAL CHECK indicator at the TCU operator's panel but do not turn on the POWER CHECK indicators at the TCU. Relay K19 is also picked by the K20 N/C points and turns on the TCU POWER CHECK indicator at the console operator's panel.

The K20 N/O points cause a thermal warning signal to be sent to the TCU logic circuitry. This signal represents an out-of-tolerance check (OTC), and it sets the attention bit in the status byte. The IOCE that is attached to the TCU recognizes this attention bit and notifies the program of the OTC condition. Note that a warning temperature condition does not start a power-off sequence.

The second check catastrophic occurs when the operating temperature in any of he logic gates exceeds 134°F. When any of these thermal sensors opens, K2 (not power check) drops and begins a normal dc power-off sequence as described in the preceding section.

Before power can be restored to the TCU, the temperature in the overheated area(s) must fall below the catastrophic temperature level. After the temperature has returned to normal, the RESET pushbutton must be depressed to pick K2 (not power check) and to begin the power-on sequence.

CONTROLS AND INDICATORS

The following controls and indicators are associated with the TCU. These controls and indicators are on the operator's control panel at the front of the TCU and at the rear panel in the prime power area. The OFF-LINE jack is on the maintenance panel.

Operator's Control Panel (Figure 9-2)

ELEMENT MPO Pull Switch

Pulling the element MPO pull switch removes TCU power within 2 seconds. However, ac power is still present at the primary ac entry point and the +24V dc power supply is still active.

Note: The MPO switch is a mechanical-latch type that must be reset manually. After this switch is reset, TCU power is automatically sequenced on if the POWER ON/OFF switches are set to ON.

POWER ON/OFF Switch

This switch removes all power within the TCU except 24V dc prime power. The switch is effective only when the TCU is in state zero and in off-line status. This POWER ON/OFF switch is in series with the AC ON/OFF switch on the rear panel.

DC ON/OFF Switch

This switch is used to apply/remove dc power to the TCU logic circuitry. After completion of a power-on sequence, the switch is effective only when the TCU is in state zero and in off-line status. This DC ON/OFF switch is in series with the DC ON/OFF switch on the rear panel.

POWER CHECK Indicator

This indicator is on when a catastrophic thermal or power supply failure has occurred.

THERMAL CHECK Indicator

This indicator is on when any of the TCU gate temperatures have exceeded the thermal warning unit. The indicator is reset by depressing the RESET pushbutton after the temperature has returned to normal.

POWER SEQUENCE COMPLETE Indicator

This indicator is on when the power sequence in the TCU is complete. The indicator is turned off when a power-off sequence is started.

METER ON/OFF Switch

This switch performs the same function in the 2803A TCU as the TEST switch on other elements in the 9020 system. The switch is wired in parallel with the OFF-LINE jack switch on the maintenance panel.

When the TCU is in state zero, either the METER ON/OFF switch (in the OFF position) or the OFF-LINE jack (plugged) can be used to remove the power interlock and allow power to be removed with the AC or DC ON/OFF switches.

LAMP TEST Pushbutton Switch

This pushbutton switch is depressed to light the indicators to test for burned-out light bulbs.

STATE Indicators

These two indicators reflect the operational state of the element (readout is in binary code). The TCU must be in state zero before a normal power-off can begin.

Maintenance Panel (Figure 9-3)

Only one control on the maintenance panel concerns power in the TCU; this is the OFF-LINE jack. This jack is effective only when the TCU is in state zero. Plugging the jack or turning the METER ON/OFF switch to OFF enables the TCU manual controls and allows a normal power-off sequence to be started.

Rear Panel – Prime Power Box (Figure 9-4)

AC ON/OFF Switch

This switch is used to perform the same function as the POWER ON/OFF switch on the operator's panel, and it removes all power from the TCU except prime +24V dc. After completion of a power-on sequence, this switch is effective only when the TCU is in state zero and in off-line status. This AC ON/OFF switch is in series with the POWER ON/OFF switch on the operator's panel.

DC ON/OFF Switch

This switch is used to apply/remove dc power to the TCU logic circuitry. After completion of a power-on sequence, the switch is effective only when the TCU is in state zero and in off-line status. This DC ON/OFF switch is in series with the DC ON/OFF switch on the operator's panel.

RESET Pushbutton

Depressing this pushbutton resets a thermal-check or power-check condition and turns off the POWER CHECK indicators.

TEST OTC Pushbutton

Depressing this pushbutton simulates an OTC (thermal warning) condition by dropping K20 (not thermal check) and setting an attention bit in the status byte.

AC ON Indicator

This indicator is on when contactor K5 (ac power on) is picked.

POWER CHECK Indicator

This indicator is on when a catastrophic thermal or power supply failure has occurred.

Circuit Breakers

CB1 through CB5 protect the five dc regulators and are for the +12V, +6V, +3V, -12V, and -3V regulators, respectively.

CB8: controls input power to the power supply and to the logic gate fans.

CB10 (Mainline): controls the 3-phase, 208V ac, 60-Hz input to the TCU from the facility service outlet.

CB9 and CB11: control the ac power to both banks of external tape drives.

Fuses and Circuit Protectors

F1 and F2: protect the 24V power supply (PS1) and ac circuitry that are concerned with power sequence and control.

F3 and F4: protect the 115V ac convenience outlet circuits.

F5 and F6: protect the 7.25V ac lines to the indicator.

F7: protects the 48V ac line.

F8, F9, and F10: used to protect the circuits that pick contactors K6, K9, and K10, respectively.

CP1: used to protect the convenience outlet circuits.

The Data Adapter Unit is present in the 9020E System only. All Data Adapter Unit components and circuits associated with power distribution and control are described in this Chapter.

POWER SEQUENCE AND CONTROL

Power Component Locations

- The operator's panel provides monitoring and control functions.
- The power area contains the dc power supplies and power-sequencing components.

Figures 10-1 through 10-3 show the DAU, its operator's panel, and its power area. Controls associated with power on the operator's panel are the POWER ON AND RESET lighted pushbutton switch/indicator and the POWER OFF IF IN LOCAL pushbutton switch.

The power area includes three dc power supplies, a LOCAL/REMOTE switch, circuit breakers, THERMAL and CB TRIP indicators, a step-down transformer (T1) which provides 24V ac for the power sequence and control circuitry, and a step-down transformer (T2) which provides 115V ac to the convenience outlets in the DAU. The dc power supplies provide voltages necessary for the SLT logic circuitry.

Power Interlock Circuit

- Each DAU is power-interlocked with the configuration console (CC).
- All main power is removed from the DAU under EPO conditions.

Power interlocking is such that all main DAU power can be removed under EPO conditions. Pulling the EPO switch on the CC removes all main power from the DAU.

Figure 10-4 shows the DAU interlock circuitry. Under normal or EPO conditions, a 24V ac service voltage is still available between the DAU and the CC. With the EPO switch closed (not pulled) at the CC and any element in the 9020E system (including the CC) providing 24V dc to pick the 9020 EPO and 2821, DAU EPO contactors, a circuit is established from the 24V ac bus in the DAU, to pin 2 of the DAU EPO jack, to the CC DAU EPO jack, through the now closed 2821, DAU EPO relay point, to pin 1 of the DAU EPO jack, through contactor K1 (EPO) in the DAU, and to the 24V ac return.

When the EPO switch at the console is opened (pulled), it drops contactor K1 in the DAU, removing all main power (Figure 10-5).

Unlike other elements of the 9020E system, the DAU cannot pick the EPO contactors in the CC. It uses only their contacts for EPO.

If the DAU LOCAL/REMOTE switch is in REMOTE, the DAU EPO circuit will also remotely power the DAU on as soon as the EPO contactors in the console are picked. This is so the DAU can automatically power-on after removal of an EPO condition in the 9020E system.

AC Distribution

- 208V, single-phase, 60-Hz input power.
- Power sequence and control circuitry also uses ac power.

The ac input consists of single-phase, 208V, 60-Hz power that is routed to the DAU directly from the facility service outlet (Figure 10-5).

Closing main ac CB1 supplies 208V ac power to T1, the 24V ac step-down transformer that supplies power for the power sequencing and control circuitry. Before further ac distribution can occur, the power-interlock circuit must be completed to the CC as described in the preceding section.

With the power-interlock circuit complete (K1 picked), 208V ac is routed to step-down transformer T2, which supplies 115V ac to the convenience outlets. As the power-on sequence proceeds (described in detail under "Power-On Sequence"), contactor K2 is picked, where upon it provides 208V ac to the SLT gate and power area fans and blowers. It also provides 208V ac to the three dc power supplies.

DC Distribution

All dc power is supplied by three regulated dc power supplies; these are all Medium Power Standard (MPS) supplies. Input to these supplies is 208V ac, single-phase power. Refer to Table 10-1 for a list of the supplies, their locations, and ratings. For the theory of operation of these supplies, refer to IBM manual SLT Power Supplies Manual of Instruction.

Table 10-1. DC Power Supplies

Location	Output	Current
F/C	- 3vdc	4.0 amp
F/G	+3vdc	16.0 amp
F/H	+6vdc	1.5 amp

Power-On Sequence, Local

- LOCAL/REMOTE switch must be in LOCAL to sequence power on locally.
- EPO condition must not be present.

See Figures 10-4 and 10-6. As explained previously, if no EPO condition is present (EPO switch at the CC not pulled), contactor K1 in the DAU is picked. If no CB is tripped and no thermal condition is present in the DAU, the N/O contacts of K1 pick relay K7 immediately. If, at this time, a CB is tripped, K7 does not pick and the CB TRIP indicator is lit; if a thermal condition exists, K7 does not pick and the THERMAL TRIP indicator is lit. The CB TRIP and THERMAL TRIP indicators cannot light together, however, even if both conditions exist. In this event, only the CB TRIP indicator will light due to the way the power circuitry is wired (Figure 10-4).

To start the power-on sequence, the POWER ON AND RESET pushbutton must be depressed. Its B-side N/O contacts then pick relay K6 through the POWER OFF IF IN LOCAL switch N/C contacts, the LOCAL/REMOTE switch contacts, and the A-side contacts of the POWER-ON AND RESET switch. The POWER-ON indicator in the POWER ON AND RESET pushbutton also lights at this time. The K/ N/O points then pick contactor K2.

Note: If the POWER ON AND RESET pushbutton is released too soon, relay K2 cannot be picked because the pick circuit for K2 is through the B-side contacts of the POWER ON pushbutton and the K6 N/O points.

When K2 picks, its N/O points gate 208V ac to all fans and blowers in the DAU and to the three dc power supplies (Figure 10-5). The K2 N/O points also provide a hold circuit for K2 by bypassing the POWER ON AND RESET B-side switch contacts, so that the POWER-ON AND RESET switch may be released.

As the dc supply outputs come up, the output of the +6V supply picks relay K4. The N/O points of K4 then hold K2 and start relay K3 (0.5-second time delay) timing out. Relay K6 should still be picked at this time through the K5 N/C points, and, as the dc supplies apply power to the SLT gates, the K6 N/O points provide a 'power-on reset' line to the DAU logic circuits.

When 0.5 second elapses, relay K3 picks and its N/O points pick relay K5. K5 then holds itself through its N/O points and drops relay K6, which was previously held through the K5 N/C points.

When K6 drops, its N/O points remove the 'power-on reset' line to the DAU logic circuitry. Power is now sequenced on in the DAU.

Power-On Sequence, Remote

- Power sequences up and down with the EPO contactor in the CC.
- LOCAL/REMOTE switch in the DAU must be in REMOTE.

See Figure 10-4. Preliminary conditions to power the DAU up with the LOCAL/REMOTE switch in REMOTE are the same regarding the CBs and thermals as those described for power sequencing with the LOCAL/REMOTE switch in LOCAL.

When the LOCAL/REMOTE switch is in REMOTE, power is controlled only the EPO switch on the console and the 2821, DAU EPO contactor in the console. As soon as any element supplies 24V dc to pick the 2821, DAU EPO contactor, its N/O points gate 24V ac from the DAU 24V ac bus, through the LOCAL/REMOTE switch, and pick K6 through the K5 N/C points. A normal power-on sequence now occurs. The only way power can be sequenced down in the DAU when in REMOTE is by dropping the 2821, DAU EPO contactor.

In summation, the DAU powers on and off with the EPO contactor in the CC when its LOCAL/REMOTE switch is in the REMOTE position.

Normal Power-Off Sequence

- LOCAL/REMOTE switch must be in LOCAL.

See Figures 10-4 and 10-7. If the LOCAL/REMOTE switch is in LOCAL, a normal power-off sequence can be started by depressing the POWER-OFF IF IN LOCAL pushbutton. When this pushbutton is depressed, its N/C contacts open and drop relays K2, K3, and K5 and turn off the POWER-ON indicator. When K5 drops, its N/C points light the appropriate DAU POWER CHECK indicator on the CC. When K2 drops, its N/O points open the 208V ac input to the dc power supplies and to all fans and blowers in the DAU. As the power supply outputs decay, relay K4 (which was picked by the output of the +6V supply) drops. Power is now off in the DAU, with only relays K1 (EPO) and K7 still picked.

Emergency Power-Off Sequence

- DAU has a unique EPO attachment to the CC.

See Figure 10-4. If the system EPO switch on the CC is pulled, it drops relay K1 in the DAU. As K1 drops, its N/O points drop all relays and open the 208V ac input to the fans and power supplies. All DAU power drops, with only the 24V ac to the EPO circuit in the CC remaining. This voltage is necessary so that power can be automatically sequenced up again in the DAU (if LOCAL/REMOTE switch is in REMOTE) when the EPO condition is removed.

Special Power-Off Sequences

The DAU can perform two special power-off sequences: overcurrent and thermal check. Each is described below.

Overcurrent Power-Off Sequence

- The DAU contains overcurrent protection by way of CBs.

The DAU contains overcurrent protection by way of CBs on the inputs and outputs of its dc power supplies. When a CB trips, its auxiliary contacts (Figure 10-4) transfer to their N/C position, providing a pick circuit for relay K7 and lighting the CB TRIP indicator.

When K7 picks, its N/O points open the circuit for contactor K2. When K2 drops, its N/O points drop all power to the fans and dc power supplies and drop all relays except K1 (EPO). The K5 N/C points light the appropriate DAU POWER CHECK indicator on the CC when poewr drops in the DAU.

To reset the overcurrent condition, the CB must be physically reset, and, if the DAU is in REMOTE, it will power-up. If it is in LOCAL, the POWER ON AND RESET pushbutton must be depressed to start a normal power-on sequence.

Thermal Check Power-Off Sequence

If one of the thermal sensing devices in the DAU activates (opens), it drops relay K7 (Figure 10-4). The N/C points of K7 light the THERMAL TRIP indicator, and the N/O points sequence power down as described under "Over-current Power-Off Sequence". The K5 N/C points again lights the appropriate DAU POWER CHECK indicator on the CC.

Power automatically sequences back up in the DAU as soon as the thermal sensor cools, if the DAU is in REMOTE. If it is in LOCAL, power can be sequenced up normally by depressing the POWER ON AND RESET pushbutton as soon as the thermal sensor cools.

CONTROLS AND INDICATORS

DAU power controls and indicators are located on the operator's panel and in the power area inside the unit.

Operator's Panel (Figure 10-2)

POWER-ON AND RESET Pushbutton Switch/Indicator

The POWER-ON AND RESET pushbutton lights to act both as a power-on switch (if DAU is in LOCAL) and as an indicator to show that power is on. This switch also picks relay K6 if power is already on and the LOCAL/REMOTE switch is in LOCAL. The N/O points of K6 provide a 'power-on reset' line to the DAU logic circuitry.

POWER-OFF IF IN LOCAL Pushbutton Switch

This pushbutton switch is depressed to provide a normal power-off sequence if the DAU is in LOCAL.

Power Area (Figure 10-3)

LOCAL/REMOTE Switch

The LOCAL position of the LOCAL/REMOTE switch permits the DAU to be powered on or off locally. The REMOTE position places DAU power-on/off under control of the CC EPO circuitry.

THERMAL TRIP Indicator

This indicator shows when a thermal condition has occurred in the DAU if a CB trip is not also present.

CB TRIP Indicator

This indicator shows that a CB on either the input to or output of a dc supply has tripped.

Circuit Breakers

CB1: controls the main 208V ac input to the DAU.

CB3 through CB5: control the 208V ac inputs to power supplies F/C, F/G, and F/H respectively.

Each dc power supply also contains an internal CB which protects its output circuit. These CBs are located on the supplies, and each is labeled CB1.

Fuses

F1: protects the 208V ac input to 24V ac step-down transformer T1.

F2: protects the 208V ac input to 115V ac step-down transformer T2.

F7 and F8: protect the 208V ac input to the SLT gate fans.

F9 and F10: protect the 208V ac input to the power supply fans.

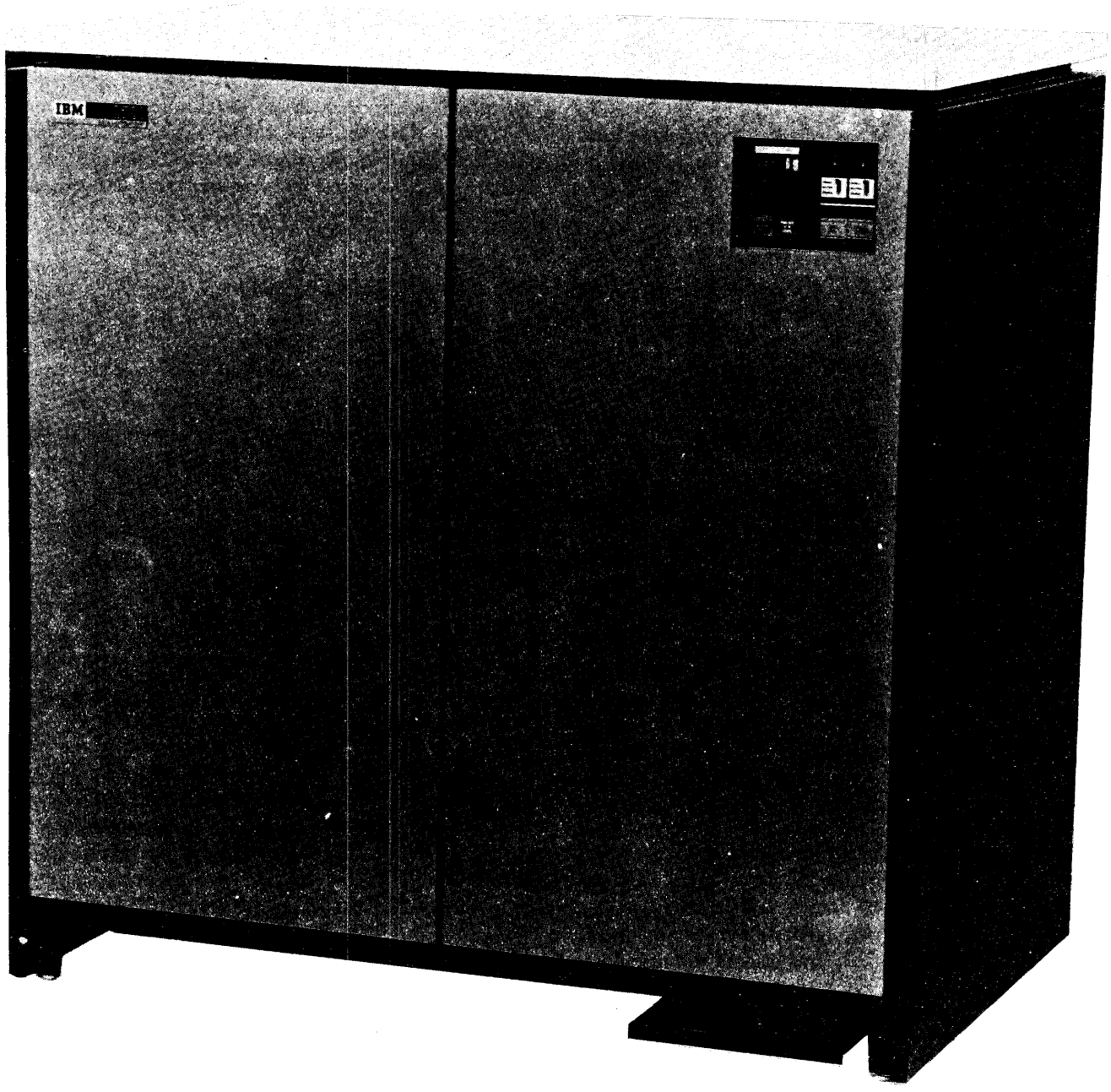


Figure 10-1. IBM 2701 Data Adapter Unit

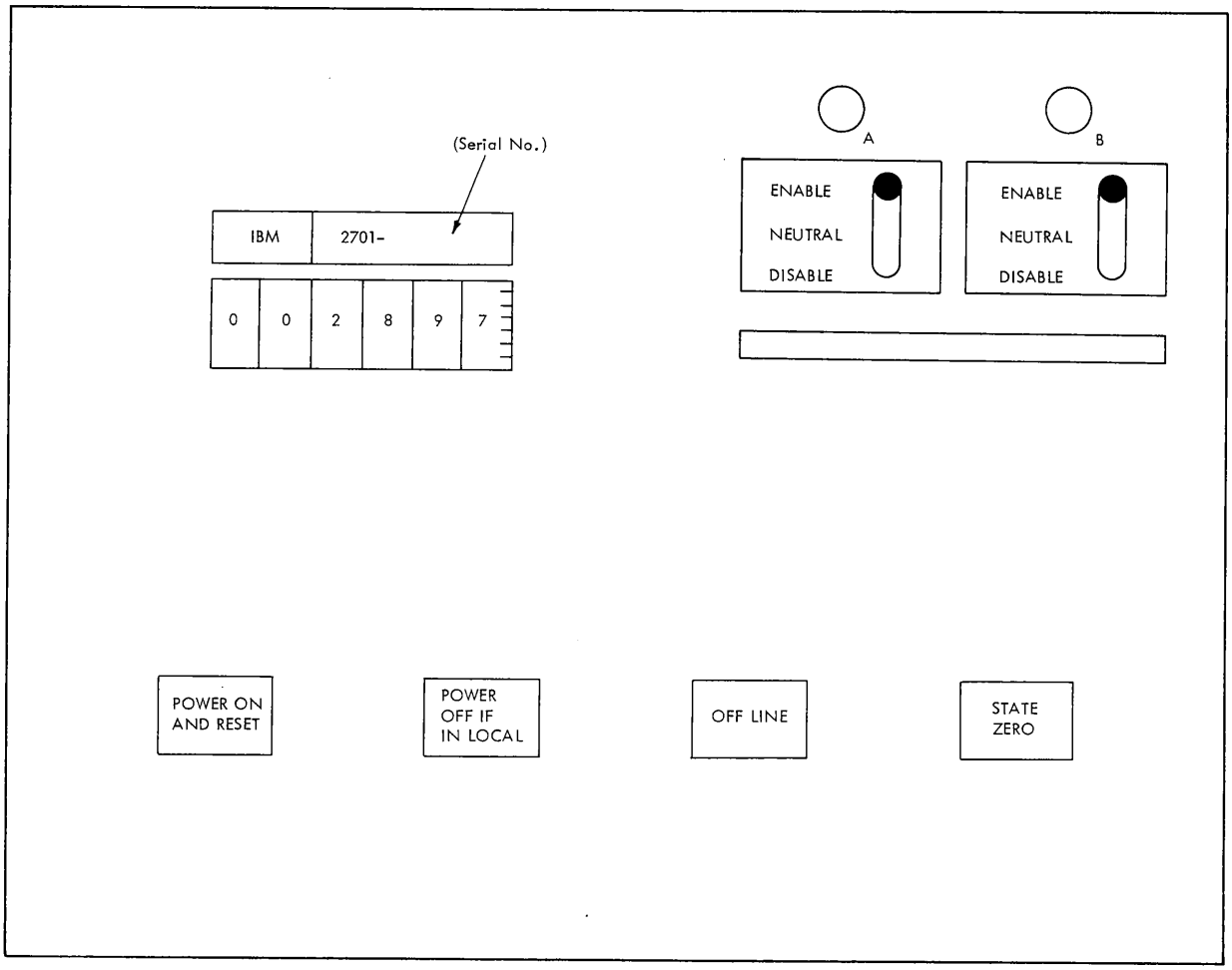
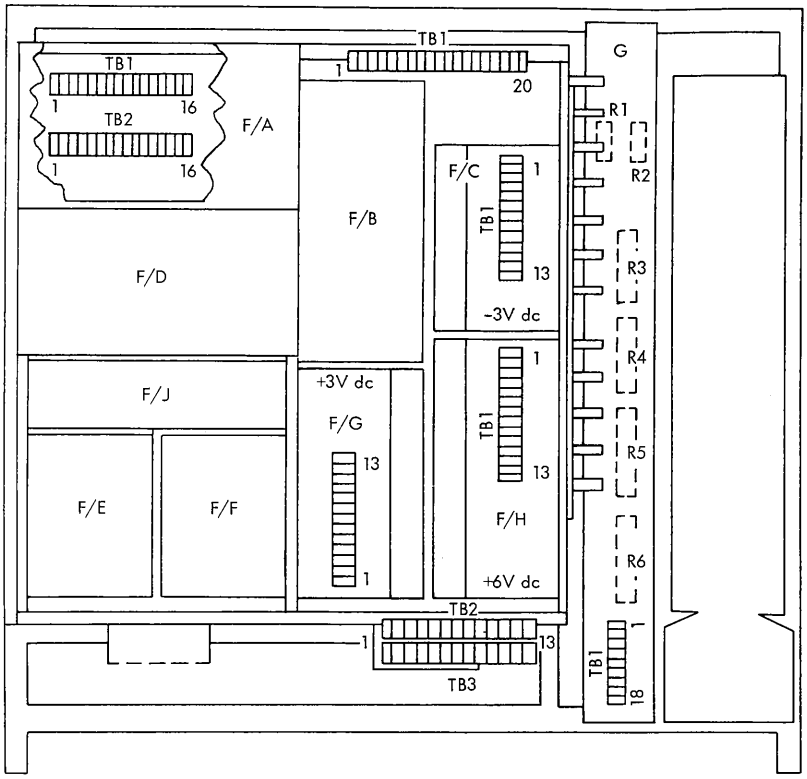
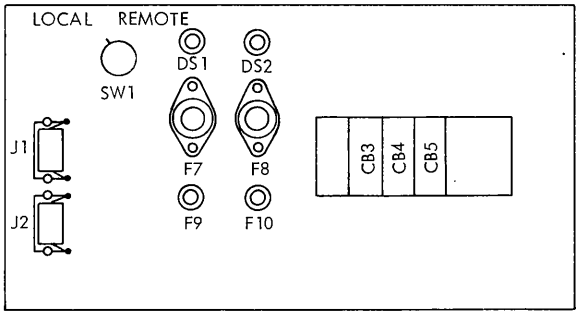


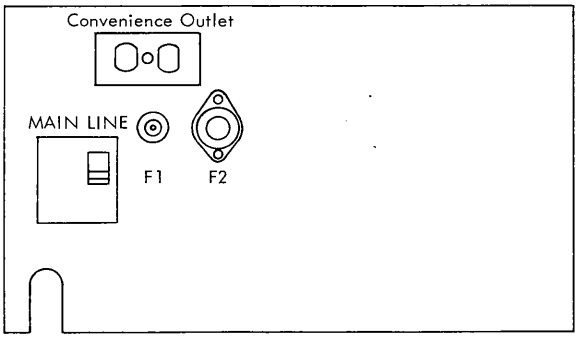
Figure 10-2. Operator's Control Panel



DAU Power Area

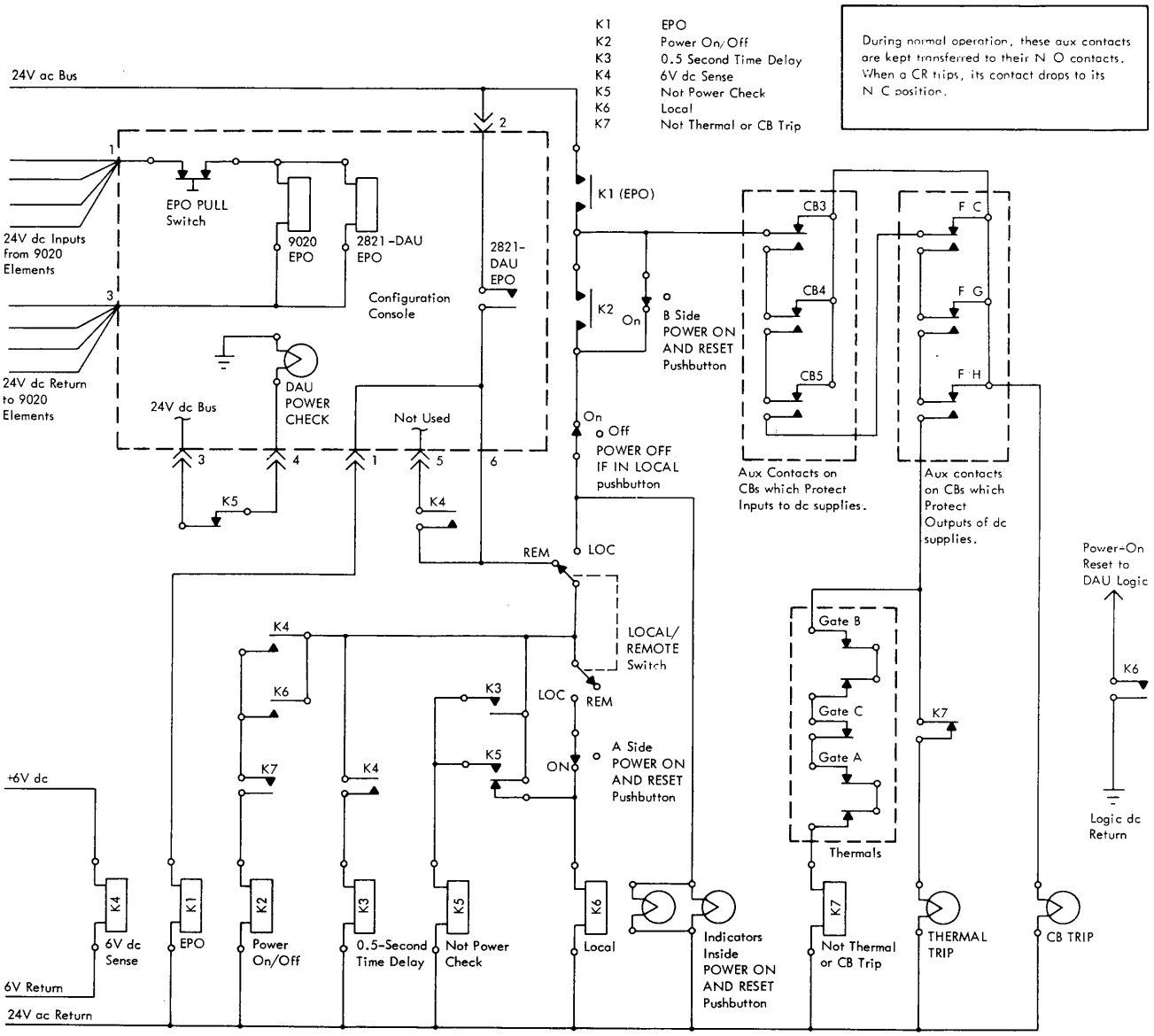


Panel F/A



Panel F/D

Figure 10-3. DAU Power Area



●Figure 10-4. DAU Power Sequence and Control Circuitry

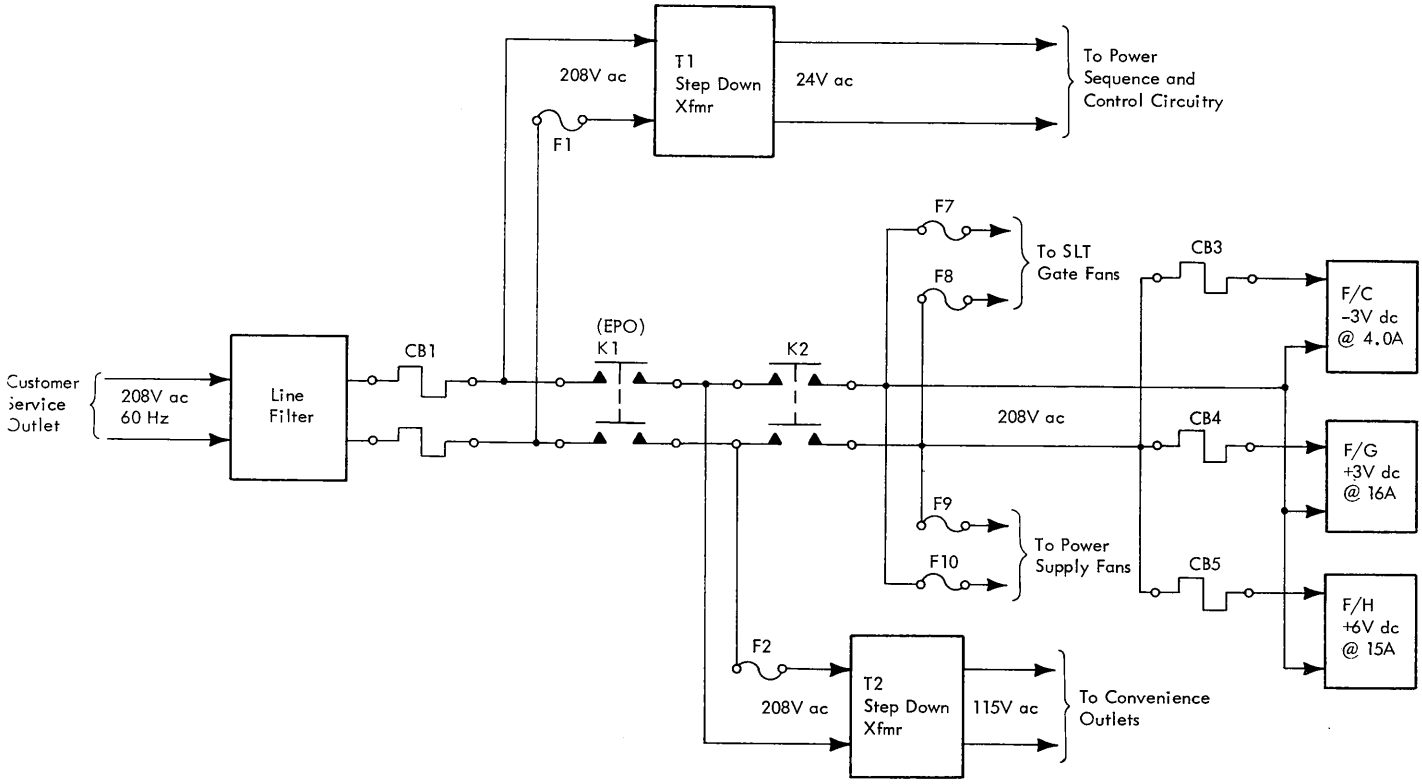


Figure 10-5. DAU AC Distribution

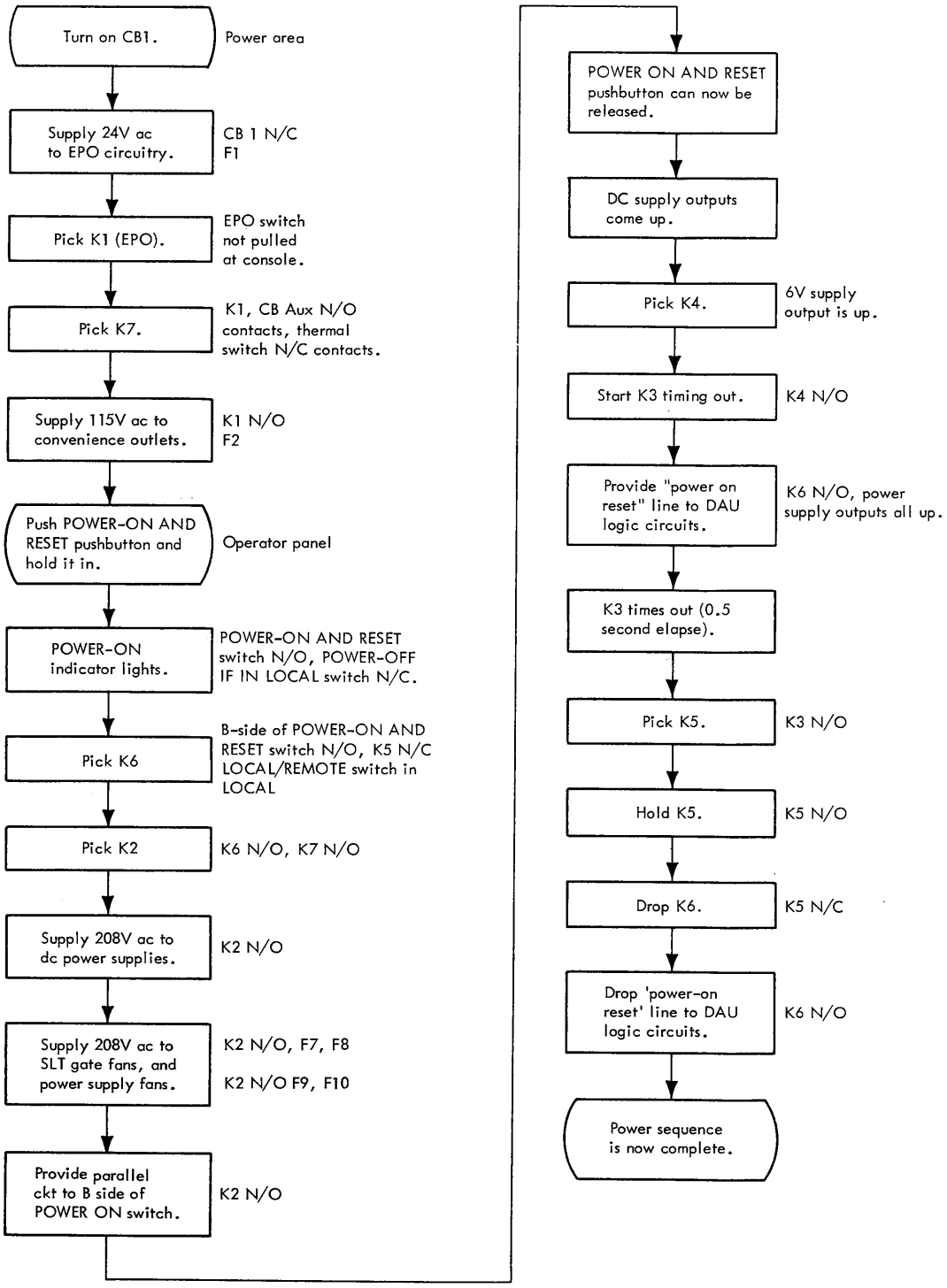

Turn on CB1.
Power area
Supply 24V ac to EPO circuitry.
CB 1 N/C F1
Pick K1 (EPO).
EPO switch not pulled at console.
Pick K7.
K1, CB Aux N/O contacts, thermal switch N/C contacts.
Supply 115V ac to convenience outlets.
K1 N/O F2
Push POWER-ON AND RESET pushbutton and hold it in.
Operator panel
POWER-ON indicator lights.
POWER-ON AND RESET switch N/O, POWER-OFF IF IN LOCAL switch N/C.
Pick K6
B-side of POWER-ON AND RESET switch N/O, K5 N/C LOCAL/REMOTE switch in LOCAL
Pick K2
K6 N/O, K7 N/O
Supply 208V ac to dc power supplies.
K2 N/O
Supply 208V ac to SLT gate fans, and power supply fans.
K2 N/O, F7, F8
K2 N/O F9, F10
Provide parallel ckt to B side of POWER ON switch.
K2 N/O
POWER ON AND RESET pushbutton can now be released.
DC supply outputs come up.
Pick K4.
6V supply output is up.
Start K3 timing out.
K4 N/O
Provide "power on reset" line to DAU logic circuits.
K6 N/O, power supply outputs all up.
K3 times out (0.5 second elapse).
Pick K5.
K3 N/O
Hold K5.
K5 N/O
Drop K6.
K5 N/C
Drop 'power-on reset' line to DAU logic circuits.
K6 N/O
Power sequence is now complete.

Figure 10-6. DAU Local Power-On Sequence Flowchart

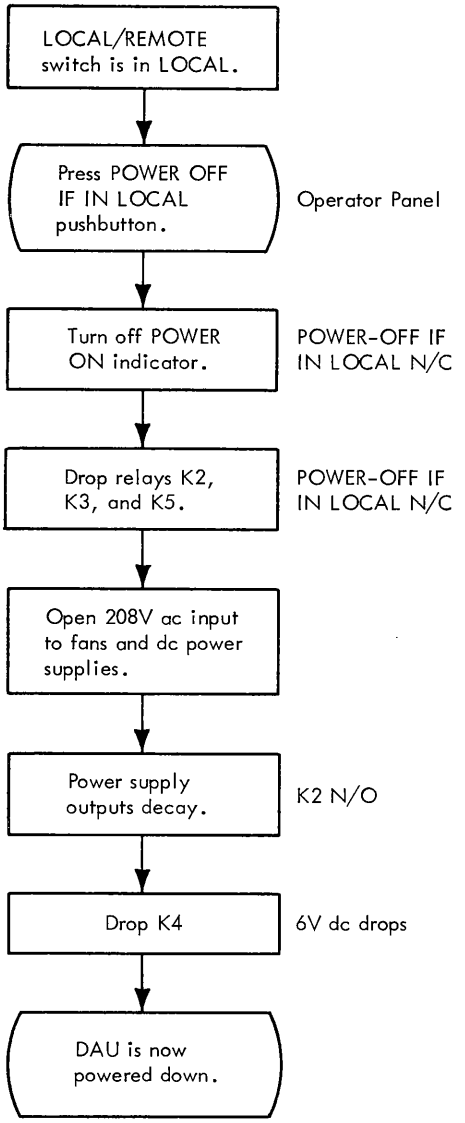

LOCAL/REMOTE switch is in LOCAL.
Press POWER OFF IF IN LOCAL pushbutton.
Operator Panel
Turn off POWER ON indicator.
POWER-OFF IF IN LOCAL N/C
Drop relays K2, K3, and K5.
POWER-OFF IF IN LOCAL N/C
Open 208V ac input to fans and dc power supplies.
Power supply outputs decay.
K2 N/O
Drop K4
6V dc drops
DAU is now powered down.

Figure 10-7. DAU Normal Power-Off Sequence Flowchart

This chapter describes power control and distribution within the IBM Direct Access Storage Facility (DASF) as affected by the FAA modifications. The DASF includes the IBM 2314-A1 Storage Control Unit (SCU) and the IBM 2312 and/or 2318 Disk Storage Unit (DSU).

POWER SEQUENCE AND CONTROL

Power Component Locations

- Operator's panel provides monitoring and control functions.
- Power area includes a mid-pack supply and a power sequence box with control functions.

Figures 11-1 through 11-7 show the SCU and its operator's control panel, maintenance panels and power area, and the DSU power panel.

The operator's panel (Figure 11-2) contains the following power controls and indicators:

1. An ELEMENT MPO PULL switch
2. A LAMP TEST pushbutton switch
3. Two state (S0, S1) indicators

The SCON and maintenance panels (Figures 11-3 and 11-4) contain the following power controls and indicators:

1. A THERMAL CHECK indicator
2. Two state (S0, S1) indicators
3. A TEST indicator
4. A CE/NORMAL/IN-LINE rotary switch
5. A POWER ON indicator
6. A POWER ON/OFF switch
7. A POWER CHECK indicator
8. A MAIN LINE ON indicator
9. A RESET & LAMP TEST switch

On the SCON cable panel, located directly behind the I/O cable panel, there is an OTC TEST pushbutton which simulates a thermal warning condition when depressed.

The power area contains a power sequence box, the mid-pack transformer power supply and regulators, the 36V power supply, and a convenience outlet transformer. The power sequence box contains the relays, main line CB, circuit protectors, fuses, and the 24V dc control supply. The mid-pack supply is made up of a three-phase transformer, rectifiers, and capacitors, all arranged to supply +12V dc, +6V dc, +3V dc, -3V dc, and -36V dc, unregulated, to the individual regulator units.

Power Interlock Circuit

- Each SCU is power-interlocked with System Console.
- All main power is removed from DASF under an EPO/MPO condition.

Power interlocking is such that all main DASF power can be removed under an EPO/MPO condition. Pulling the EPO switch on the System Console removes power from all elements; pulling the SCU MPO switch removes power only from that DASF.

Figure 11-8 shows the SCU interlock circuitry. Under normal or EPO/MPO power-off conditions, a +24V dc service voltage is still available between all elements and the System Console. When the EPO switch is closed (normal) at the console, the SCU (or any element) can pick and hold the EPO contactor. In the SCU, the circuit is from the +24V dc power source, through an isolation diode, to the console through the EPO switches and EPO relay coil, and to the 24V dc return.

The EPO contactor in the console provides a pick circuit for the MPO contactor (K1), to the console through the EPO N/O contacts, and to the 24V dc return.

AC Distribution

- 208V, three-phase, 60-Hz input power.
- SCU supplies ac power to DSUs.
- Under normal power-off conditions, ac power is only available to +24V dc control supply and convenience outlets.

o 115V ac is available to convenience outlets.

The ac input consists of three-phase, 208V, 60-Hz power that is routed directly from the facility outlet (Figure 11-9). Closing main ac CB1 supplies 208V ac, single-phase power to the +24V dc prime power supply. Before further ac distribution can occur, the power interlock circuit must be completed to the console, as described in the preceding section.

With the power-interlock circuit complete, the picked points of relay K6 provide 115V ac to the convenience outlets. When a normal power-on sequence is initiated, relay K7 picks through N/O K5 points. The picked K7 points then provide 208V ac to the DSUs, to the gate fans, to the +36V dc supply, and to the mid-pack supply. The mid-pack supply feeds the +12V dc, -36V dc, +6V dc, -3V dc, and +3V dc regulators.

DC Distribution

- Mid-pack supply furnishes +6V dc, +3V dc, -3V dc, -36V dc, and +12V dc to SCU.
- SCU furnishes +6V dc, +3V dc, -3V dc, -36V dc, and +36V dc to DSUs.
- A separate supply is used to provide +36V dc.

The SCU contains the necessary power supplies to provide voltages for its own operation and for operation of the disk drives. The SCU power supplies furnish +6V dc, +3V dc, -3V dc, +12V dc, and -36V dc for internal use, and +6V dc, +3V dc, -3V dc, -36V dc, and +36V dc for use by the disk drives.

The +6, +3, -3, +12 and -36 volts are derived from the mid-pack power supply which consists of a three-phase transformer, rectifiers, and capacitors. The unregulated dc voltages from the mid-pack supply are then fed to the individual regulator units. Each regulator unit consists of built-in regulation circuitry, a pluggable voltage regulator SMS card, a pluggable overvoltage sensing SMS card, and an overcurrent circuit-breaker switch. Each regulator has a separate screwdriver-operated trim potentiometer for adjustment.

A separate power supply is used to provide unregulated +36V dc to the disk drives. It has a ferroregulator transformer and is not adjustable.

Power-On Sequence

- Power-on is initiated by POWER ON/OFF switch on maintenance panel.
- After an EPO/MPO condition has been corrected, DASF will power up automatically.

Refer to the ac distribution diagram (Figure 11-9), power sequence and control diagram (Figure 11-8), and power-on flowchart (Figure 11-10). To power up the DASF, the power-interlock circuit must be completed as described under "Power Interlock Circuit."

With the SCU in test mode (CE/NORMAL/IN-LINE switch in the CE position), the POWER ON/OFF switch provides a path to pick relays K4 and K5 (power-on pick). The K5 points pick relay K7 (power on) which furnishes 208V, three-phase, 60-Hz power to the DSUs, the +36V dc supply, the gate fans, and the mid-pack supply. The outputs from the mid-pack supply provide the dc voltages required for the logic in the DASF. The K5 points start a 2-second time delay and pick relay TD1. Relay K9 (logic voltage) picks when +6V dc is available, and the K9 points, in conjunction with the K4 points, pick relay K2 (power-on hold). The points of K2 provide a hold path for relay K7. Relay K3 (ready) picks after TD1 times out and is held by the same circuit as K2. After the power-up sequence is complete, the CE/NORMAL/IN-LINE switch should be placed in the NORMAL position for normal operation. If an EPO/MPO condition occurs, the DASF will power down. However, the DASF will automatically power up once the EPO/MPO switch has been closed. No intervening action is required.

Normal Power-Off Sequence

- SCU must be in state zero and in test mode (CE/NORMAL/IN-LINE switch in CE position).
- All power (except 24V dc control supply) is removed.
- AC power to the DSUs is removed when SCU powers down.

Refer to Figures 11-8, 11-9, and 11-11. To begin a normal power-off sequence, the SCU must be in state zero and in test mode (relay K21 normal). Setting the POWER ON/OFF switch to OFF removes the hold circuit to relays K4 and K5 (power-on pick). The K4 and K5 points (now normal) remove the hold circuit for relays K3 (ready) and TD-1 (time delay). After the head extended switch opens, relays K2 (power-on hold), K7 (power on), and K9 (logic voltage) drop.

Relay K7 points remove the input to the mid-pack supply, the +36V dc supply, the gate fans, and the DSUs. Relay K6 (convenience outlet) and the +24V dc supply remain energized as long as CB1 is closed. Relay K1 (MPO) stays transferred as long as +24V dc is active in any element in the system.

Note: To prevent noise on the interface, it is necessary to activate the DRIVER DEGATE switch before setting the POWER ON/OFF switch to OFF. This, however, does not affect the power-down sequence.

Emergency Power-Off Sequence

- EPO/MPO conditions immediately remove all power except the +24V dc supply.

If either the system EPO or the SCU MPO pull switch is pulled, all power is removed beyond the prime power box, except the prime +24V dc supply. These EPO/MPO switches are mechanical-interlock switches that must be reset manually by maintenance personnel.

This emergency power-off sequence is similar to that of switching the POWER ON/OFF switch to OFF while in Test mode. The differences are that the power-interlock circuit (K21) has no effect and the power sequence relays are all simultaneously de-energized.

Under EPO/MPO conditions, +24V dc is still available within the power-interlock cable that connects the SCU and the console. This voltage is necessary so that power can automatically sequence up when the EPO/MPO condition is removed.

Special Power-Off Sequence

Two categories of power-off sequences are described below. The sequences result from the detection of a power-check (overvoltage/overcurrent) condition or an overtemperature (thermal) condition in a logic gate. Figure 11-12 is a flowchart of special power-off sequence.

Power Check (Overvoltage/Overcurrent) Power-Off Sequence

- An overvoltage/overcurrent condition causes a dc power-off.

An overvoltage protection circuit is provided in each regulator (except-36V dc regulator) to detect an overvoltage condition at the output of that regulator and to short the output circuit to ground upon detecting an overvoltage condition. Each power supply is protected from an overcurrent condition by a circuit breaker (CP). A short to ground in the output circuit of a regulator, caused by detecting an overvoltage condition, or an abnormally high current demand from circuitry causes a CP to open. An open CP drops relays K2 (power-on hold) and K3 (ready). K2 point drops relay K7 (power on) which removes the input to the mid-pack supply and drops the dc voltages.

To restore dc voltages, reset CP, set CE/NORMAL/IN LINE switch to CE and set POWER ON/OFF switch to OFF then back to ON.

Thermal Check Power-Off Sequence

- A warning temperature condition does not sequence power-off.

- A catastrophic temperature condition initiates a dc power-off sequence.

Two thermal checks (warning and catastrophic) can occur in the SCU. The first check (warning) occurs when the SCU operating temperature reaches 108°F in any of the logic gates. When any thermal sensor opens, relay K20 (thermal warning) drops and the K20 points turn on the THERMAL CHECK indicator on the maintenance panel. In addition, the K20 points generate an OTC condition in the SCU logic which sends a pulsed ELC to the CEs. The OTC condition also sets bit 3 of sense byte 4. The program has the option of performing a sense command, if desired, upon receipt of the pulsed ELC. Note that a warning temperature condition does not start a power-off sequence.

The second check occurs when the operating temperature of any gate exceeds 120°F. If any thermal sensor opens, K9 (logic voltage) drops. K9-1N/O points open and drop relays K2 and K3. Relay K7 points open and remove ac input to the dc supplies, DSUs, and gate fans.

To restore voltages after temperature has returned to normal, set CE/NORMAL/IN LINE switch to CE and set POWER ON/OFF switch to OFF then back to ON.

DSU Power-On Sequence

- SCU must be powered on.

- AC Disconnect switch must be closed.

- Disk pack must be installed.

Figure 11-13 is a flowchart of the power-on sequence in the DSU. Figure 11-14 shows the associated power controls on the DSU operator's panel. Figure 11-15 shows the overall power sequence and control circuits for the upper drive.

Whenever power is on in the SCU, operational voltages are supplied to the DSU. The 208V ac is supplied to the gate blower and to the 36V transformer ('ac safety') in the DSU, provided that the AC Disconnect switch for the drive (located on the DSU power panel) is closed. When the AC Disconnect switch is open, ac is removed from the drive and the 36V 'ac safety' voltage is not developed. Absence of 'ac safety' results in a Select Lock condition if the attempt is made to power up the drive. There are several other possible causes for Select Lock, however, including absence of a dc voltage and various logic failures.

When the START/STOP switch on the first drive is set to the START position, relay K2 (sequence) is picked. Relay K8 (motor) then picks, provided that the Index Block, Front Cover Interlock, and Pack-On switches are closed. The closed contacts of K8 provide 208V ac power to the drive motor and to the filter fan motor. With relay K8 picked, relay K12 (brush cycle) is also picked and supplies power to the brush motor which starts a 60-second disk-cleaning cycle.

When the disk speed reaches 60% of its final value, relay K1 (speed) is picked and the '+36V dc sequence pick' voltage is supplied to the next drive. The +36V dc is also used to energize the head load latch magnet and the extend solenoid and to enable the hydraulic control solenoids (forward, slow, intermediate, and detent).

During the brush cycle, the access assembly moves to hydraulic home. At the end of the brush cycle, the brush switch points transfer to drop K12 (brush cycle). The access assembly then moves forward at fast speed and the heads are mechanically loaded. Then the access assembly returns to hydraulic home, seeks forward to track 000, and detents. A detent transducer signals 'detent in' which results in 'seek ready'. The 'seek ready' signal turns on the green ready light on the DSU operator's panel.

DSU Power-Off

Power is removed from the DSU when the SCU is powered down. The only other provision for removing power is the AC Disconnect switch; one switch is provided for each drive and, when open, removes power from the 36V transformer (ac safety) and from the drive, filter fan, and brush motors.

CONTROLS AND INDICATORS

The following controls and indicators associated with the DASF are located on the SCU operator's panel, the SCU SCON panel, the SCU maintenance panel, the DSU power panel, and on the DSU operator's panel.

SCU Operator's Panel

LAMP TEST Pushbutton

This pushbutton is depressed to test the indicators of the SCU operator's panel for burned-out light bulbs.

S0, S1 Indicators

These indicators reflect the element state of the SCU (binary code). SCU must be in state 0 for a normal power-off sequence.

ELEMENT MPO PULL Switch

Pulling the ELEMENT MPO PULL switch removes SCU power within 2 seconds. However, ac power is still present at the primary ac entry point, and the +24V dc power supply is still active.

Note: The MPO switch is a mechanical-latch type that must be reset manually by maintenance personnel. After this switch is reset, SCU power is automatically sequenced on if the POWER ON/OFF switch is set to ON.

SCU SCON Panel

THERMAL CHECK Indicator

This indicator is on when the operating temperature has exceeded 108°F or when the TEST OTC pushbutton is depressed.

POWER CHECK Indicator

This indicator is on when one of the following conditions exists:

1. Power-off due to an OV/OC condition.
2. Power-off due to an overtemperature condition (120°F).
3. Normal power off operation has occurred.

S0, S1 Indicators

These indicators reflect the element state of the SCU in binary code. SCU must be in state 0 for a normal power-off sequence to begin.

TEST Indicator

This indicator is on when SCU is in state 0 and CE/NORMAL/IN LINE switch is in CE. The indicator must be on for a normal power-off to begin.

MAIN LINE ON Indicator

This indicator is on when power is being supplied to the SCU and DB1 is closed.

SCU Maintenance Panel

POWER Indicator

This indicator is on when the power sequence in the SCU is complete. The indicator is turned off when a power-off sequence is started.

POWER ON/OFF Switch

This switch initiates normal power-off or power-on sequence but is effective for power-off only if the SCU is in test mode (state 0 and CE/NORMAL/IN LINE switch in CE).

CE/NORMAL/IN LINE Switch

This switch must be in CE position for normal power-off or power-on.

RESET & LAMP TEST Switch

This switch provides a means of testing all indicators on the SCU maintenance panel and a means to reset SCU logic if CE/NORMAL/IN LINE switch is in CE.

DSU Power Panel

AC Disconnect Switch (AC SW 1)

This switch allows maintenance personnel to disconnect ac power from the brush, disk drive, filter fan motors, and the 36V transformer (ac safety).

DSU Operator's Panel

Drive ID and Ready Indicator

This indicator has a green lens with the drive physical location (A–J) imprinted on it. The indicator turns on at completion of the head loading sequence; it is off during a seek operation.

SELECT LOCK Indicator

This indicator has a red lens which indicates any of the following five different malfunctions in the associated drive:

1. 'Head failure' latch indicates more than one head selected at a time.
2. 'Write failure' latch indicates:
   DC write current and not write gate.
   DC erase current and not erase gate.
   Write gate and no ac write current.
   Write current and not erase current.
3. 'Read-write failure' latch indicates read gate or not file ready and either write gate or erase gate.
4. DC power failure.
5. AC line failure.

START/STOP Switch

This switch controls power-off or power-on for its associated drive but is effective only if the SCU has power on.

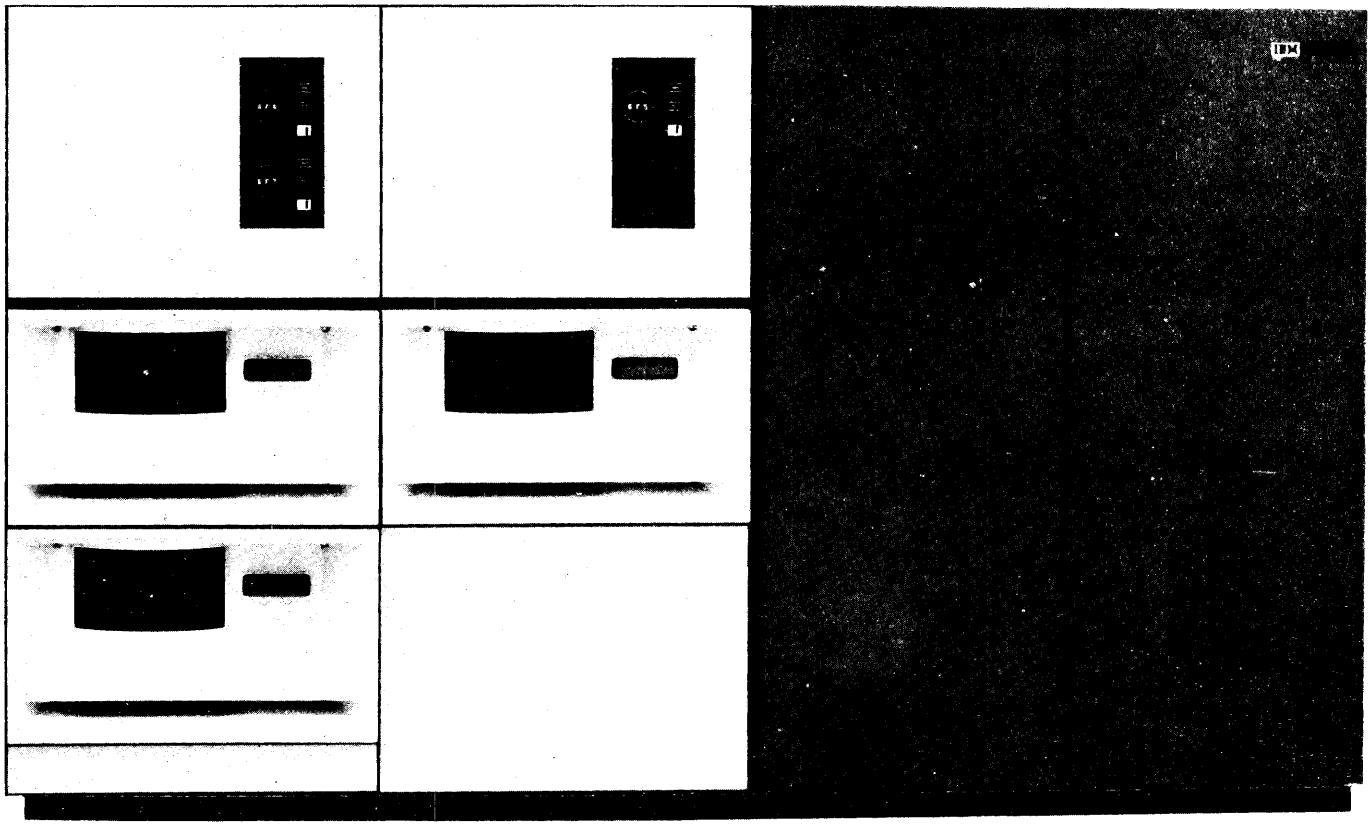


Figure 11-1. Direct Access Storage Facility (DASF)

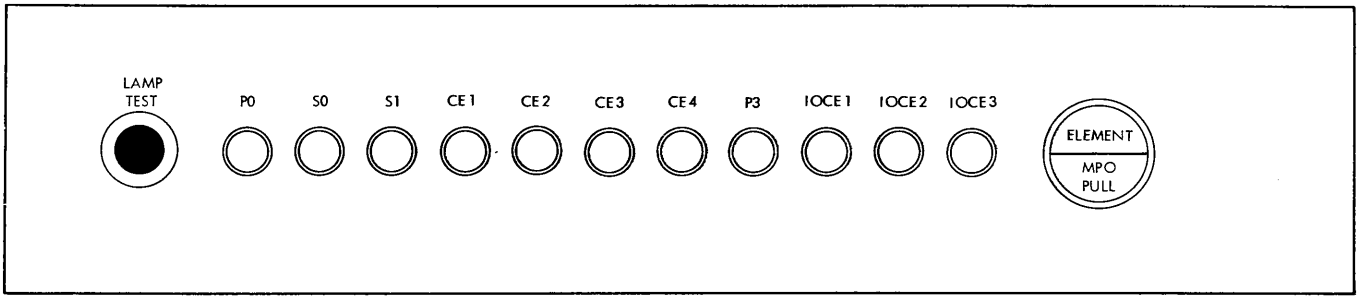


Figure 11-2. SCU Operator's Panel

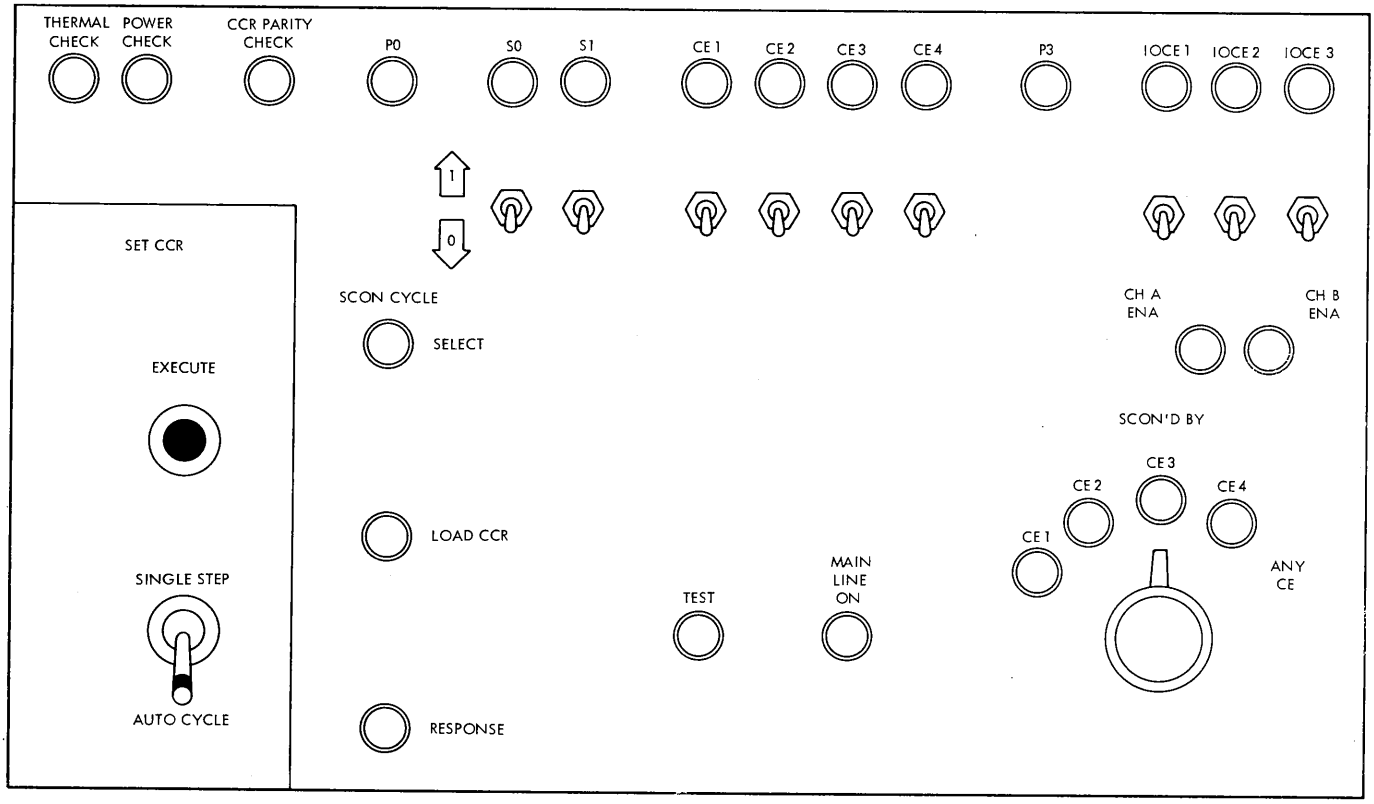


Figure 11-3. SCU SCON Panel

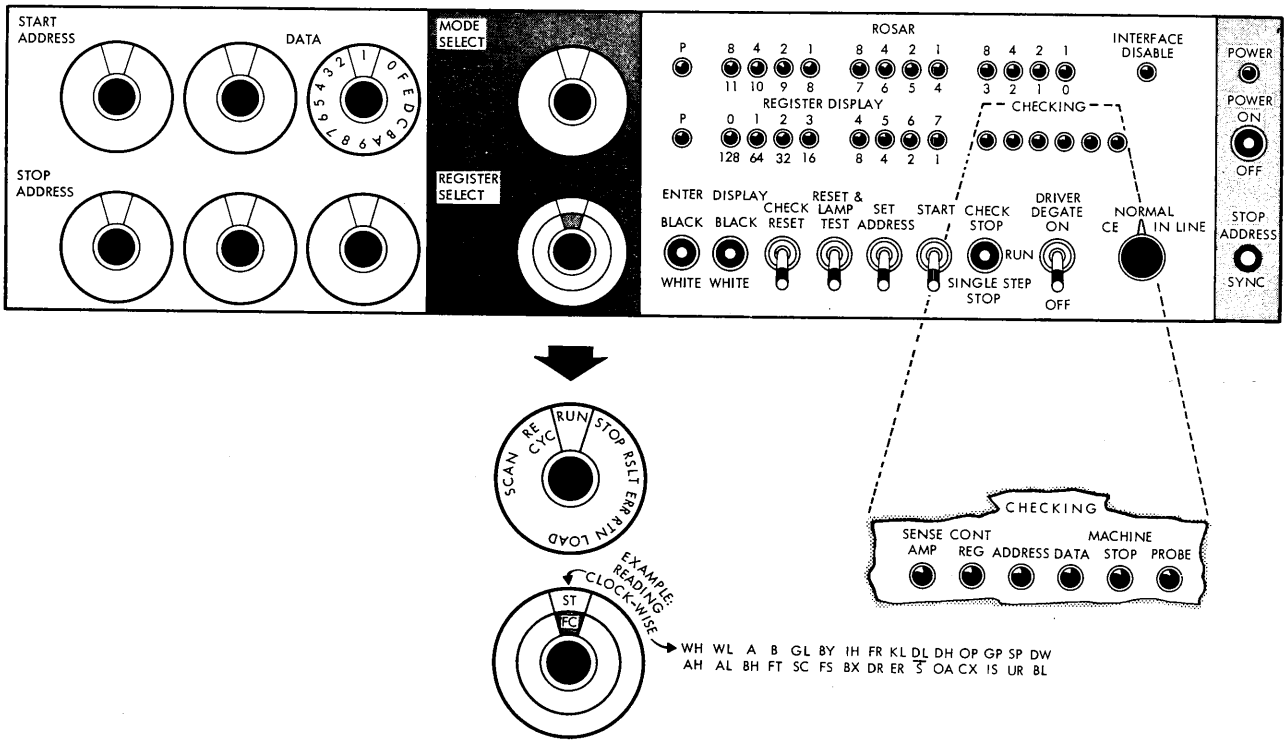
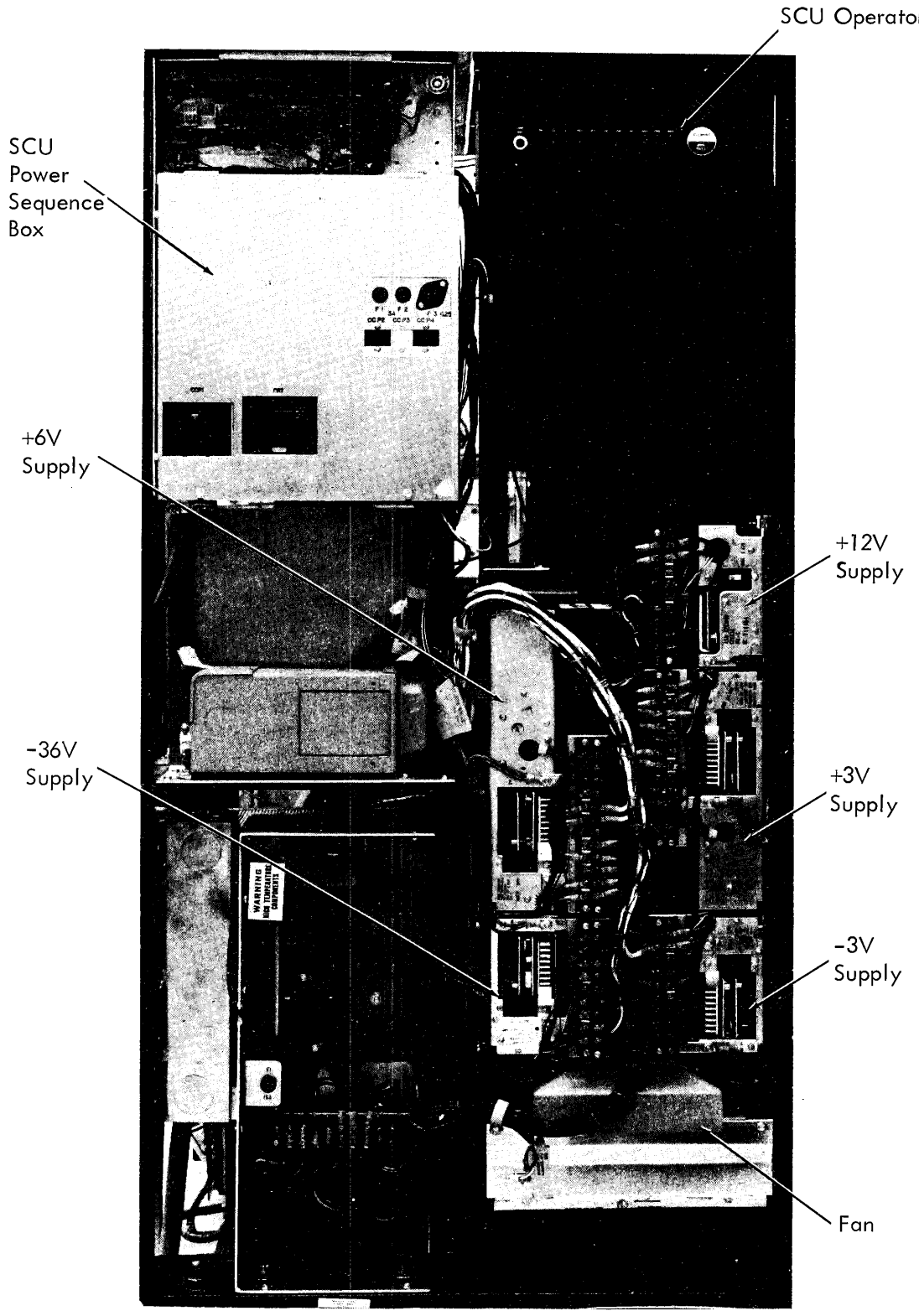
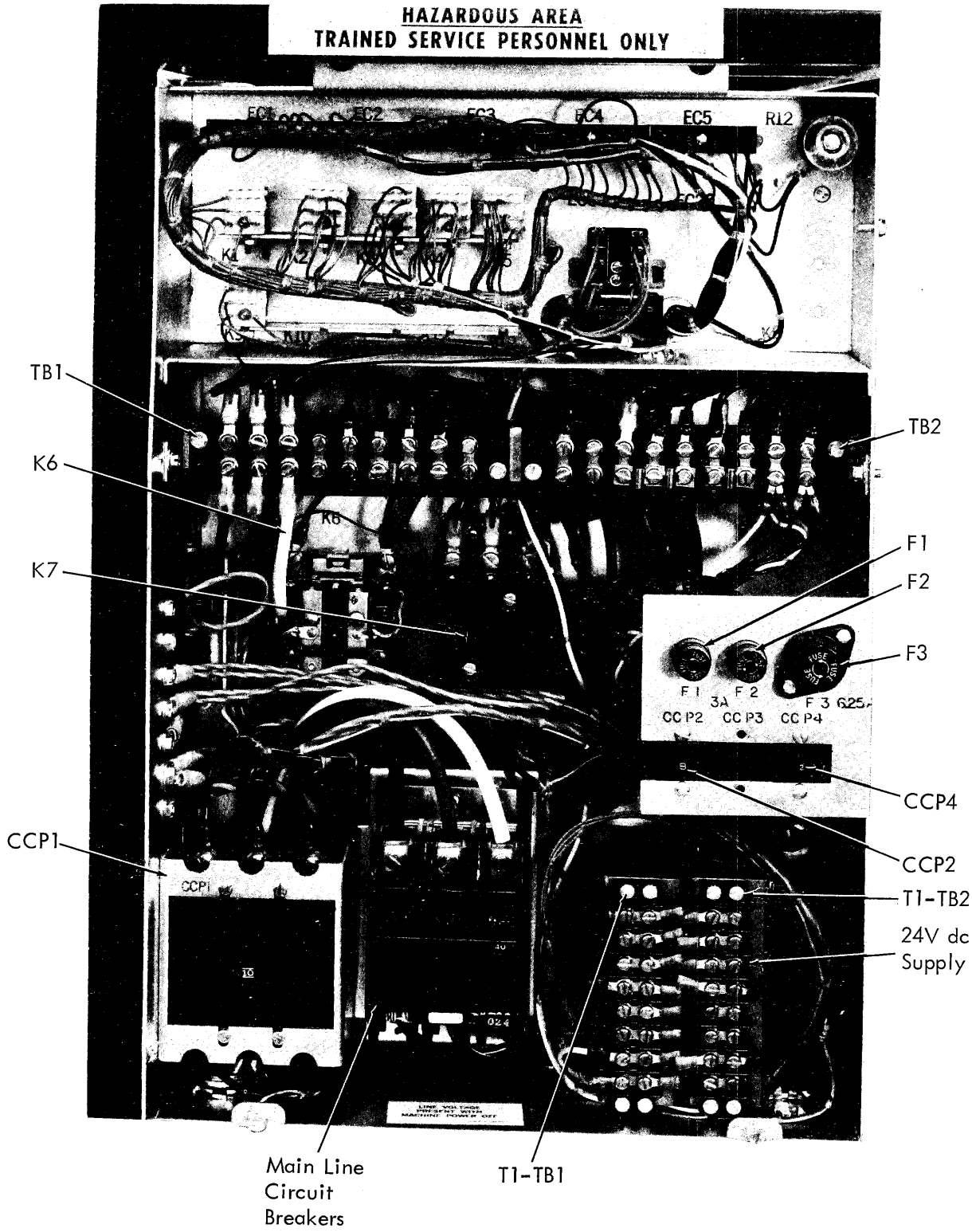


Figure 11-4. SCU Maintenance Panel



●Figure 11-5. SCU RH End



●Figure 11-6. SCU Power Sequence Box

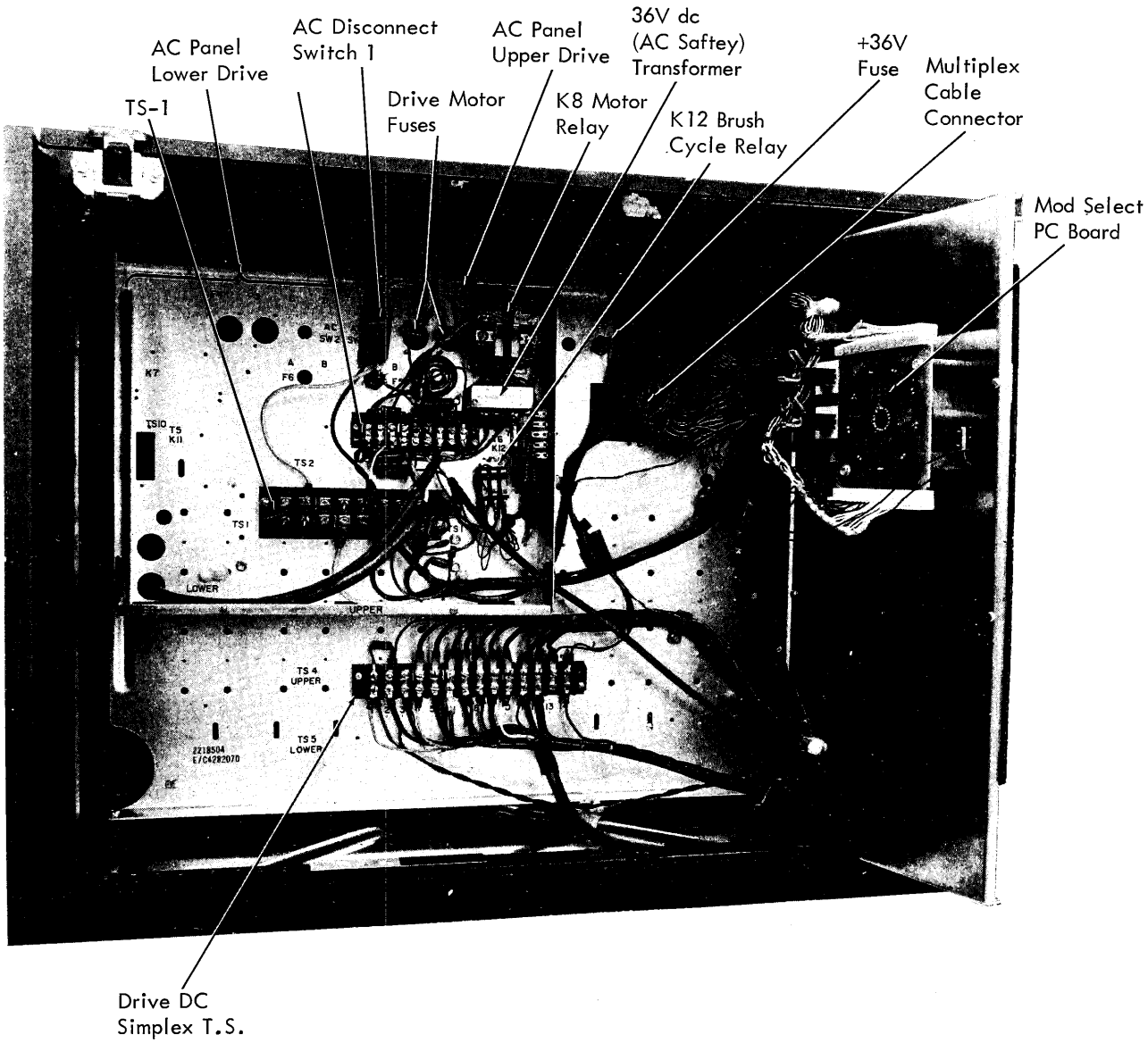


Figure 11-7. DSU Power Panel

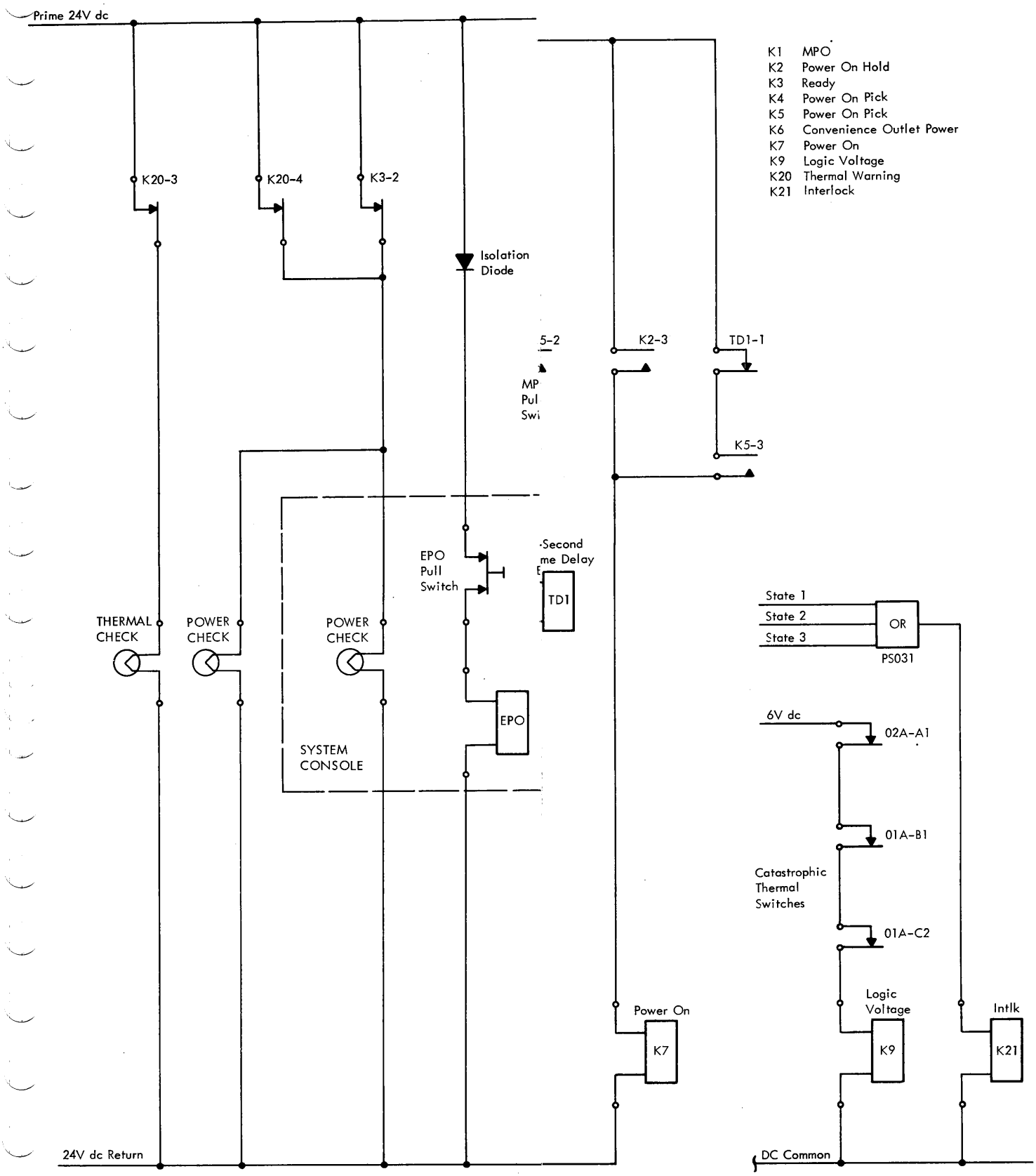
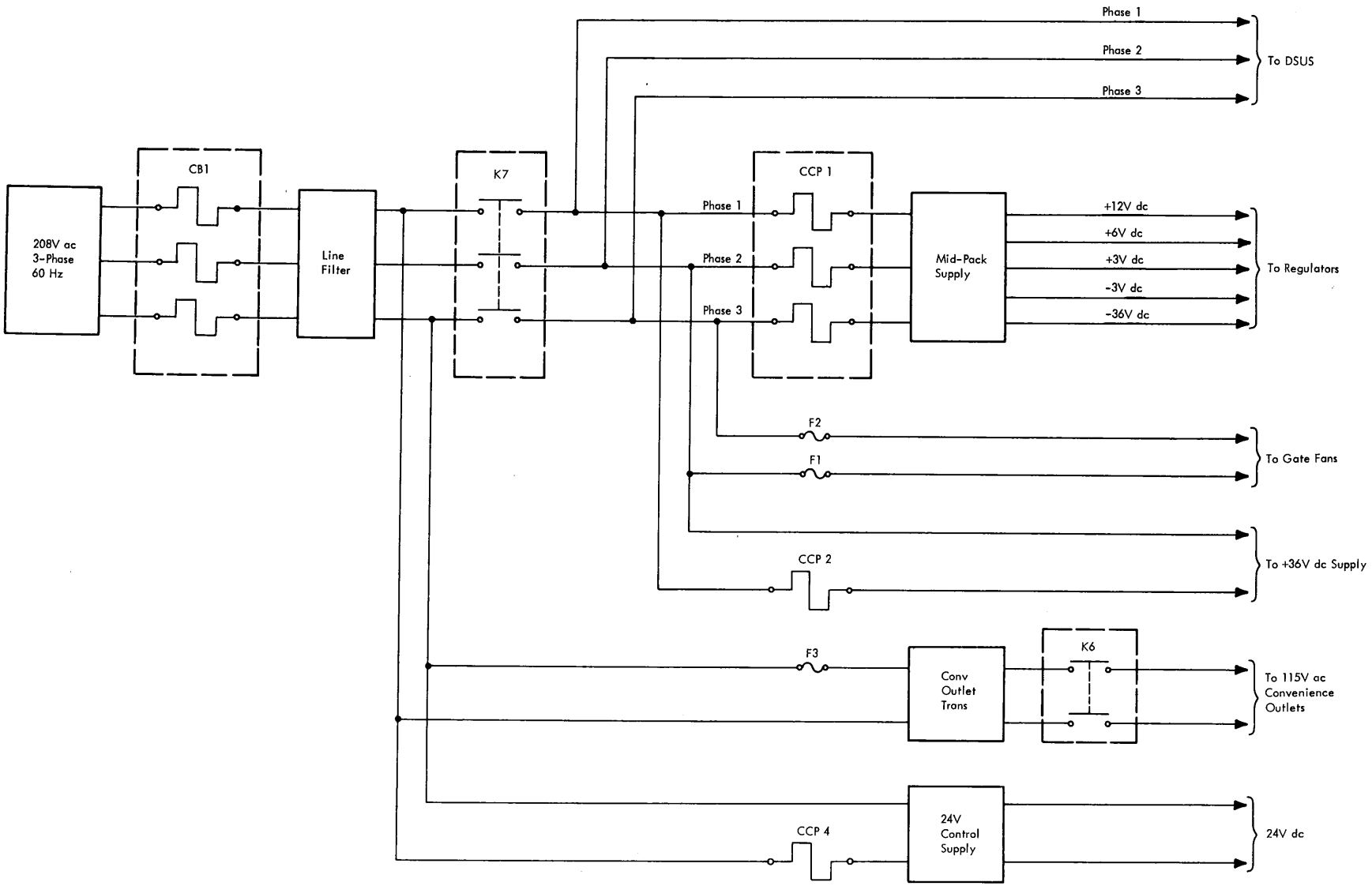
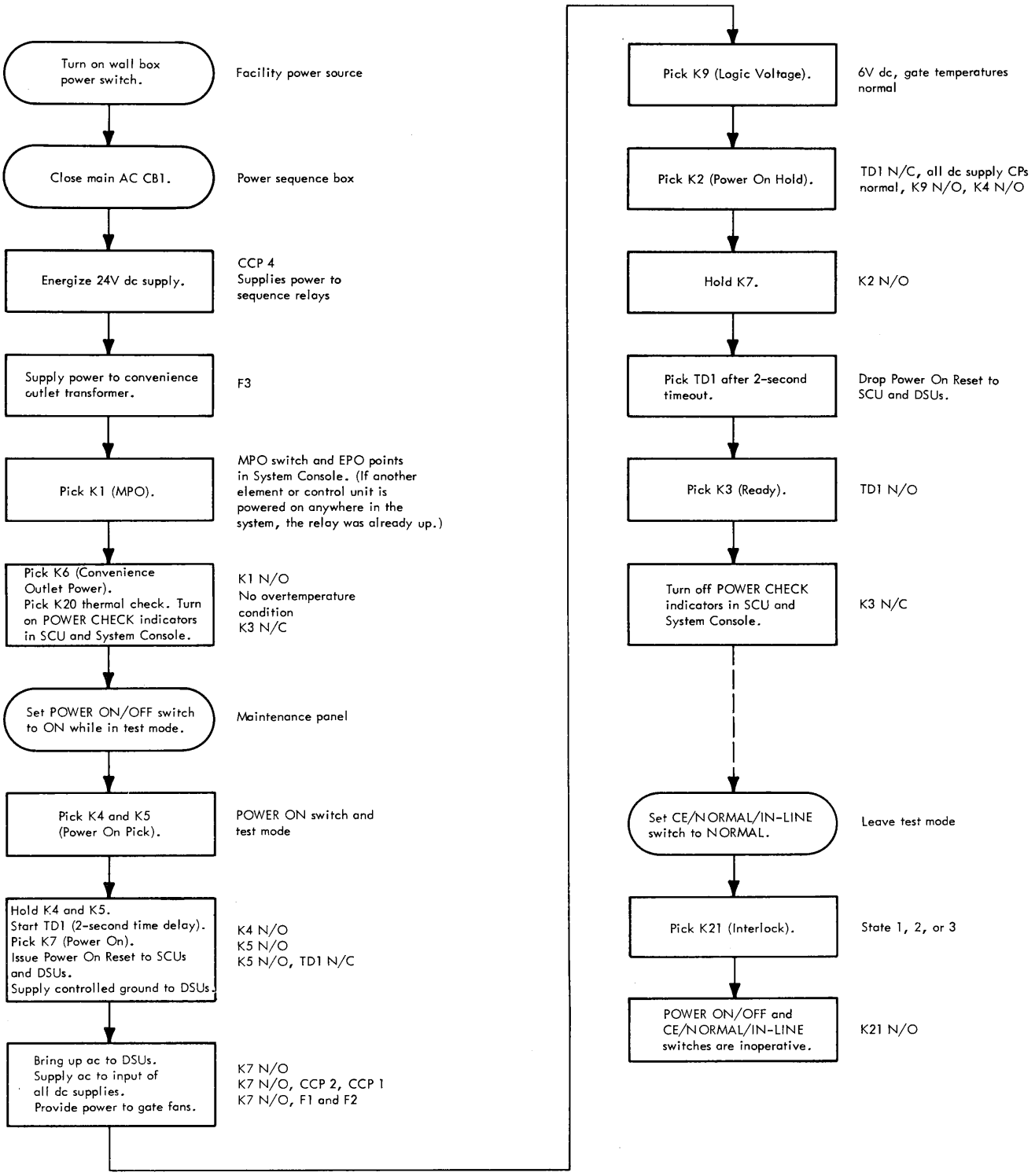


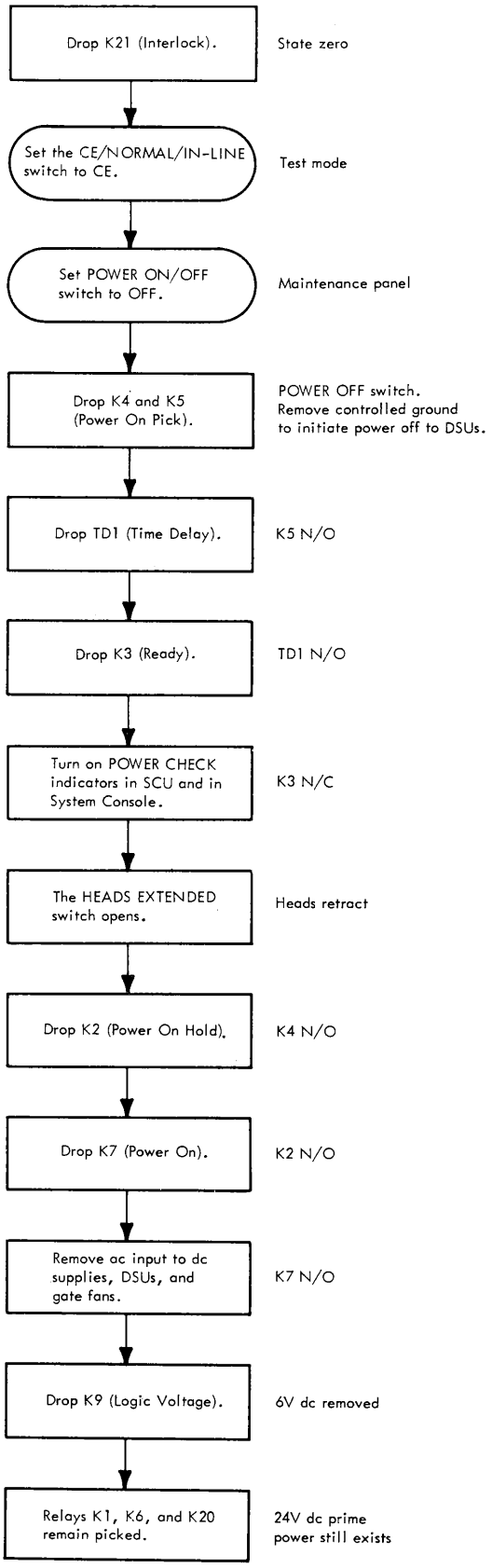
Figure 11-8. SCU Power Sequence and Control Circuitry



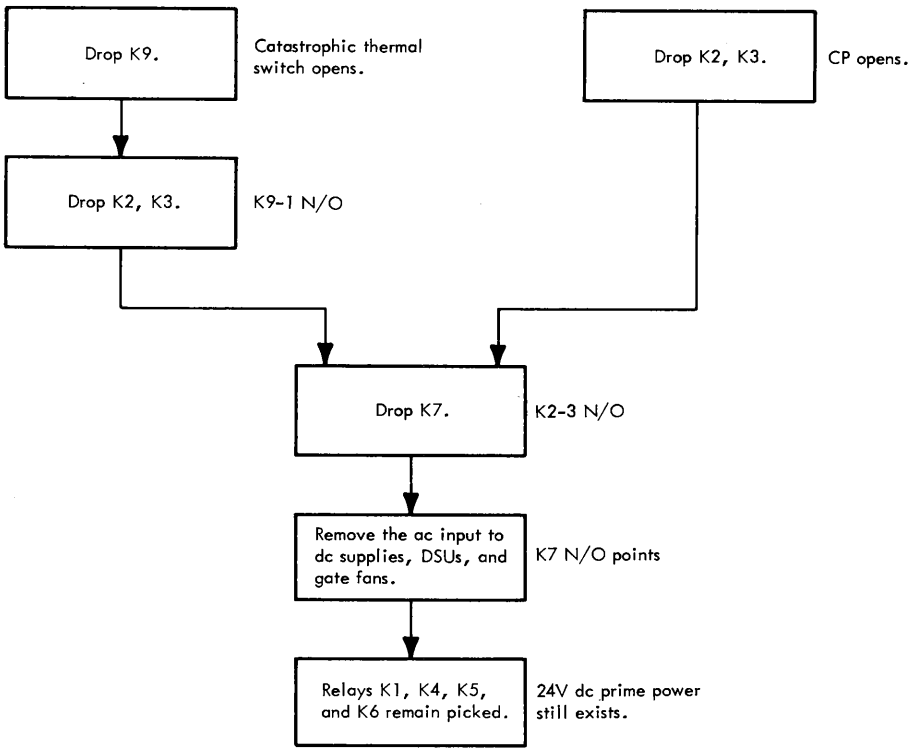
●Figure 11-9. SCU AC Distribution


Turn on wall box power switch.
Facility power source
Close main AC CB1.
Power sequence box
Energize 24V dc supply.
CCP 4
Supplies power to sequence relays
Supply power to convenience outlet transformer.
F3
Pick K1 (MPO).
MPO switch and EPO points in System Console. (If another element or control unit is powered on anywhere in the system, the relay was already up.)
Pick K6 (Convenience Outlet Power).
Pick K20 thermal check. Turn on POWER CHECK indicators in SCU and System Console.
K1 N/O
No overtemperature condition
K3 N/C
Set POWER ON/OFF switch to ON while in test mode.
Maintenance panel
Pick K4 and K5 (Power On Pick).
POWER ON switch and test mode
Hold K4 and K5.
Start TD1 (2-second time delay).
Pick K7 (Power On).
Issue Power On Reset to SCUs and DSUs.
Supply controlled ground to DSUs.
K4 N/O
K5 N/O
K5 N/O, TD1 N/C
Bring up ac to DSUs.
Supply ac to input of all dc supplies.
Provide power to gate fans.
K7 N/O
K7 N/O, CCP 2, CCP 1
K7 N/O, F1 and F2
Pick K9 (Logic Voltage).
6V dc, gate temperatures normal
Pick K2 (Power On Hold).
TD1 N/C, all dc supply CPs normal, K9 N/O, K4 N/O
Hold K7.
K2 N/O
Pick TD1 after 2-second timeout.
Drop Power On Reset to SCU and DSUs.
Pick K3 (Ready).
TD1 N/O
Turn off POWER CHECK indicators in SCU and System Console.
K3 N/C
Set CE/NORMAL/IN-LINE switch to NORMAL.
Leave test mode
Pick K21 (Interlock).
State 1, 2, or 3
POWER ON/OFF and CE/NORMAL/IN-LINE switches are inoperative.
K21 N/O

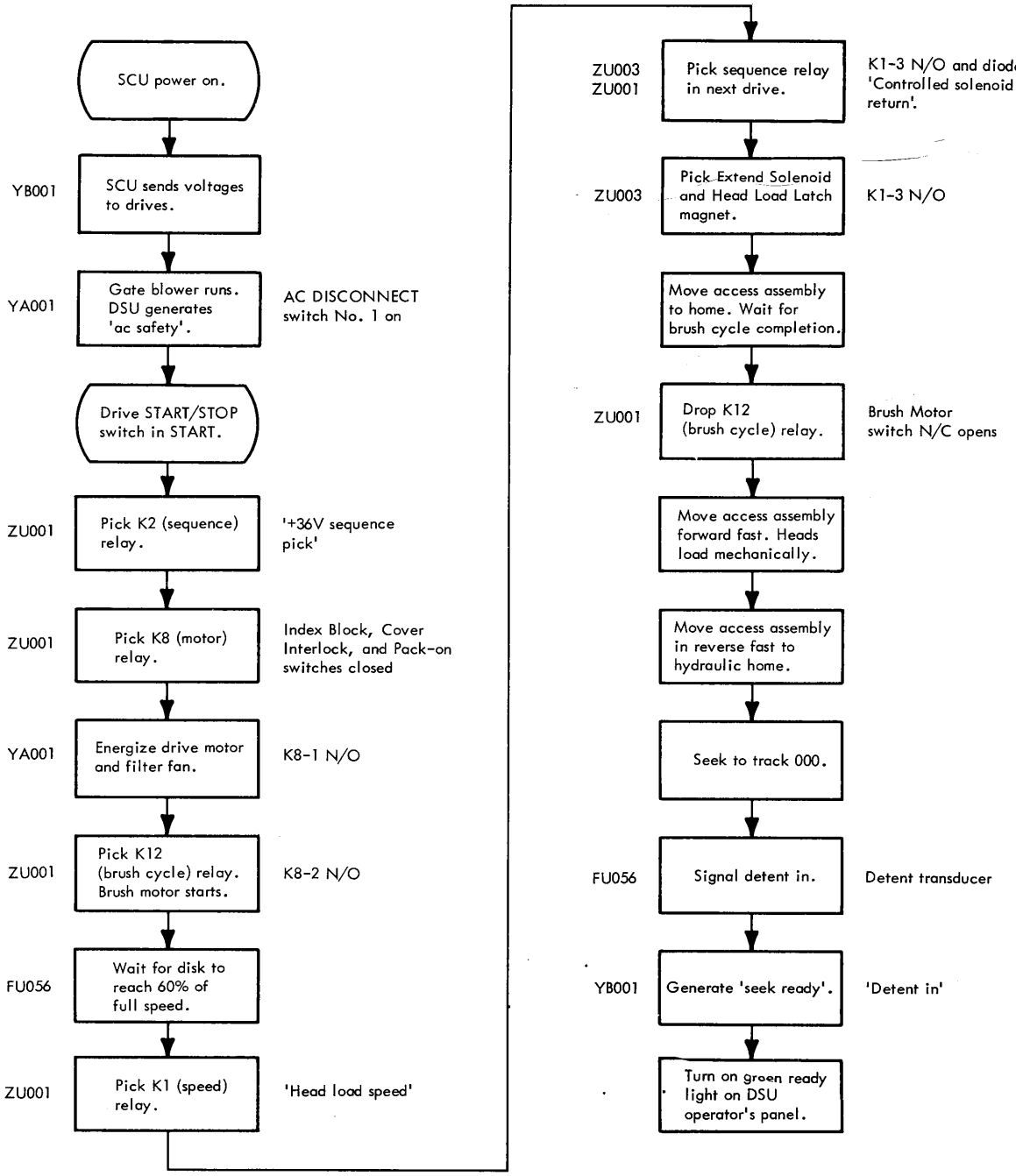
●Figure 11-10. SCU Power-On Flowchart


Drop K21 (Interlock).
State zero
Set the CE/NORMAL/IN-LINE switch to CE.
Test mode
Set POWER ON/OFF switch to OFF.
Maintenance panel
Drop K4 and K5 (Power On Pick).
POWER OFF switch. Remove controlled ground to initiate power off to DSUs.
Drop TD1 (Time Delay).
K5 N/O
Drop K3 (Ready).
TD1 N/O
Turn on POWER CHECK indicators in SCU and in System Console.
K3 N/C
The HEADS EXTENDED switch opens.
Heads retract
Drop K2 (Power On Hold).
K4 N/O
Drop K7 (Power On).
K2 N/O
Remove ac input to dc supplies, DSUs, and gate fans.
K7 N/O
Drop K9 (Logic Voltage).
6V dc removed
Relays K1, K6, and K20 remain picked.
24V dc prime power still exists

●Figure 11-11. SCU Normal Power-Off Flowchart


Drop K9.
Catastrophic thermal switch opens.
Drop K2, K3.
CP opens.
Drop K2, K3.
K9-1 N/O
Drop K7.
K2-3 N/O
Remove the ac input to dc supplies, DSUs, and gate fans.
K7 N/O points
Relays K1, K4, K5, and K6 remain picked.
24V dc prime power still exists.

●Figure 11-12. SCU Special Power-Off Flowchart



Note:
This figure refers to upper drive logic. For lower drive logic, ZU and FU pages become ZL and FL.

●Figure 11-13. DSU Power-On Flowchart

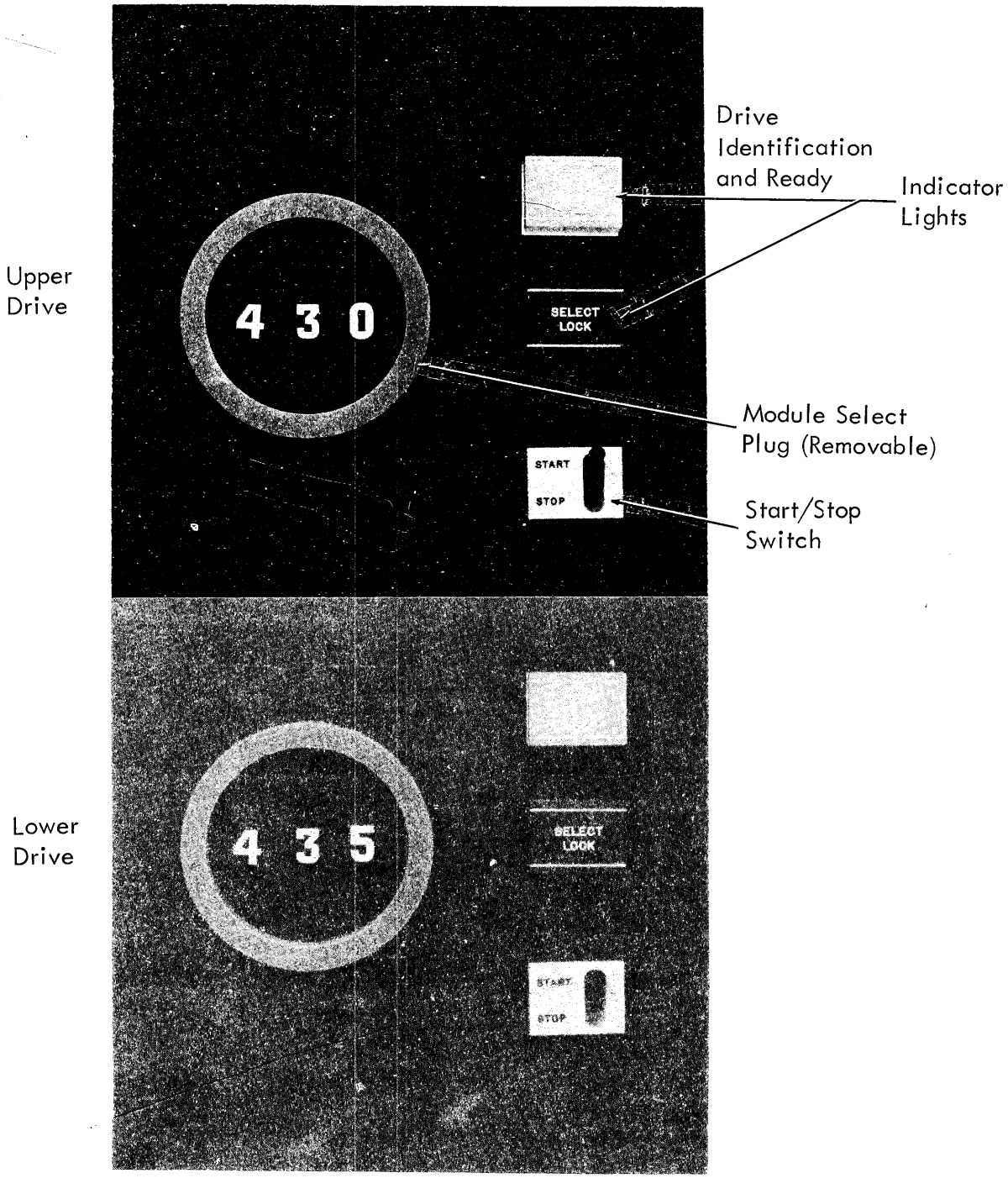
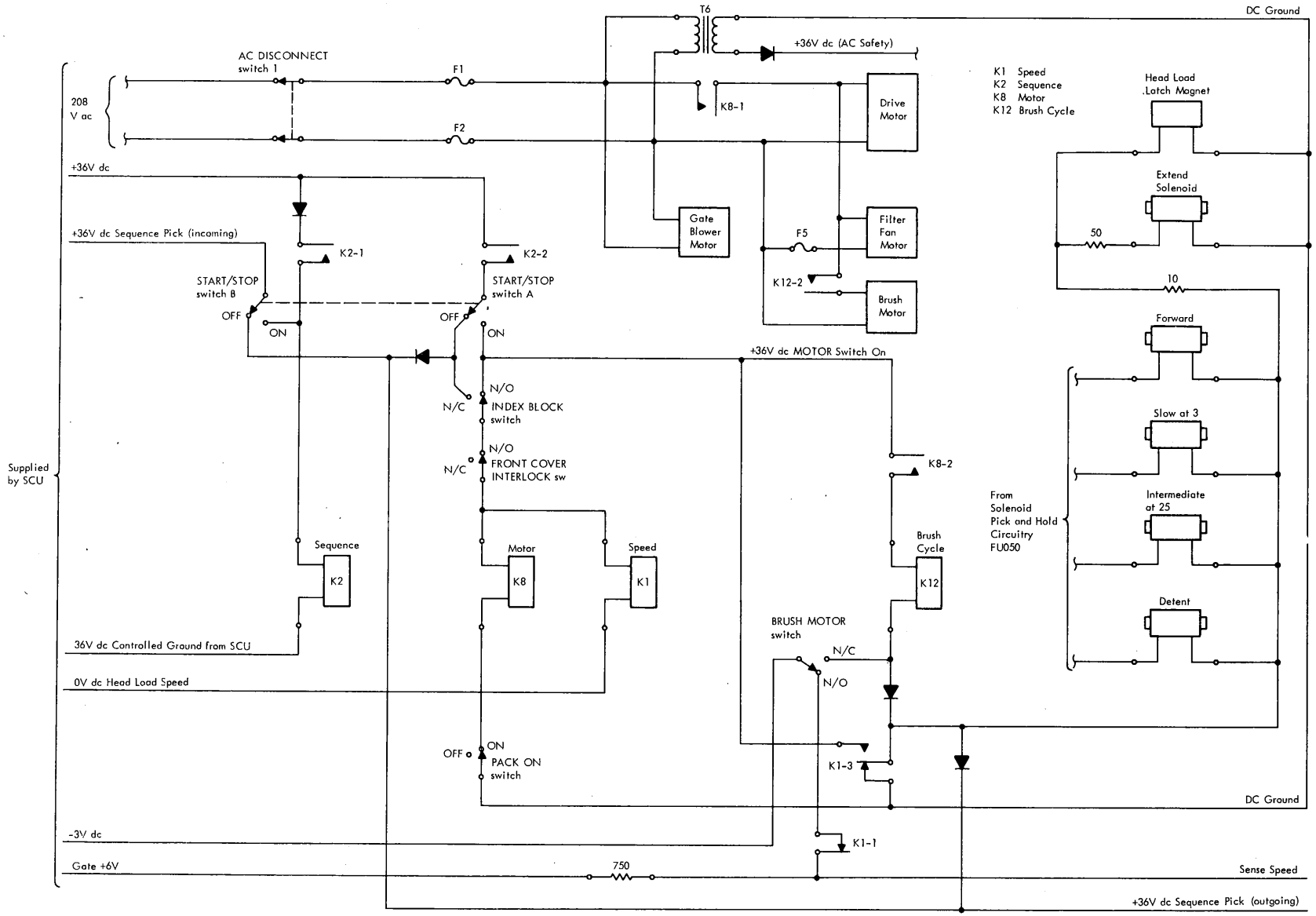


Figure 11-14. DSU Operator's Panel



● Figure 11-15. DSU Power Sequence and Control Circuitry

Note: This index is subdivided into ten sections to reflect the ten elements/units described in this manual. The sections are arranged in alphabetical order:

Computing Element
Configuration Console
Data Adapter Unit
Direct Access Storage Facility
Display Element
Input/Output Control Element
Peripheral Adapter Module
Storage Element
System Console
Tape Control Unit

To obtain information concerning a particular element or unit, the reader must refer to the appropriate index section.

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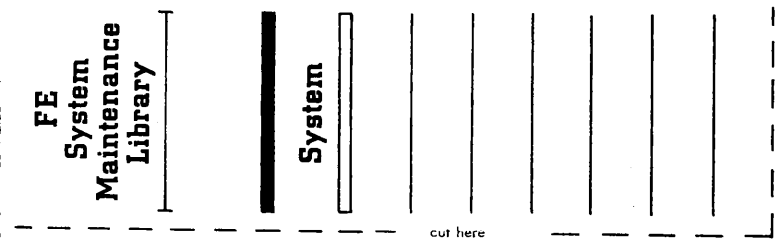

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